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Page

Editorial 325

ORIGINAL ARTICLES

Coconut Cultivation in the Island of Trinidad, British West Indies. By W. V. D. Pieris, M.A., Dip. Agric. (Cantab.), B.Sc. (Lond.) .. 328

The relative Resistance of some Strains of Bitter-gourd to the Cucurbit Fruit-fly. By M. Fernando, Ph.D., D.I.C. (Lond.) and S. B. Udurawana 347

A note on some Preliminary Cold Storage Investigations relating to Ceylon Fruits. By A. W. R. Joachim, Ph.D. (Lond.), Dip. Agric. (Cantab.), F.I.C., and T. H. Parsons, F.L.S., F.R.H.S. .. 353

Poisoning of Cattle by Artificial Manures. By M. Crawford, M.R.C.V.S. 359

SELECTED ARTICLES

The Selection and Propagation of Limes 362

The Failure of Pure and High-Grade European Cattle in Hot Climates.. 368

MEETINGS, CONFERENCES, &c.

Minutes of the Board of the Tea Research Institute held on April 4, 1941 375

CORRESPONDENCE

A Leaf Spot Disease of Annual Phlox.. 380

Premature Fall of Coconuts 381

RETURNS, &c.

Animal Disease Return for the Month ended May, 1941 .. 382

Meteorological Report for the Month ended May, 1941 .. 383

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EDITORIAL

EUROPEAN CATTLE IN CEYLON

THE contribution to *The East African Agricultural Journal*, April 1941, by Dr. M. H. French in which he describes the failure of pure European cattle and of high-grade crosses in hot climates and which we reproduce on page 368 *et seqq.* of this number is of special interest to this Island at the present moment when the Department of Agriculture is trying to establish a herd of pure European cattle at Bopatalawa. The reader will naturally want to know whether the Department is ignoring the experience of the whole of the tropical and sub-tropical world, for Dr. French is recording not only his own conclusions but those of workers in widely separated countries with the one common factor of a hot climate, such as the Southern States of America, the Philippines, South and Central Africa, India, Tropical Australia, and the West Indian Islands. These conclusions may be summarized as follows :—

1. Pure European cattle bred in the Tropics gradually lose their type : they fail to maintain their form and constitution. It is difficult to rear calves, and, when they survive under special care, development is arrested at the age of about six months. Environmental factors other than nutrition and care are responsible for their subnormal development.
2. While the first cross of the European male with the cow of the Zebu type—and generally, though not always, the reciprocal cross—produces a good dairy cow, further grading-up leads to constitutional failure and the eventual triumph of environment over heredity.

This experience is doubtless a depressing one. They have induced the Indian Government to turn its back on all imported types of cattle : the catalogue of the All-India Cattle Show has no class for European breeds and their crosses. But there are certain considerations which make one hope that the last word has not been said on the subject. The scale of the trials from which the adverse conclusions are drawn does not appear in

many cases to have been sufficiently extensive to exclude the possibility that the results are not universally true. Dr. French himself has recorded the reservation that his results "do not mean that European cattle cannot do extremely well inside the Tropics if they live at an altitude at which the climate simulates that of temperate zones. Under such conditions very little degeneration of type is observed". Experiments in pure breeding have not been carried to a point at which it could be determined whether a local breed of foreign origin inferior to the ancestral degree of excellence but superior to the good Zebu types cannot eventually be established by the progressive retardation of the tendency to degenerate. The importance of such a development may be estimated from the fact that, with a daily average of 59 cows in milk, the Scindhi herd in the Imperial Dairy Expert's farm at Bangalore yielded only an average of 3,390 lb. of milk per cow for the year ending June 30, 1940. In these conditions a degenerate Friesian or an Ayrshire cow which would give 5,000 lb. with the same kind of feeding would be a valuable asset to a local dairyman. Trials in crossing have not been sufficiently sustained to determine whether, by the alternation of grading-up and grading-down, and inbreeding amongst selected specimens, a new breed with the high productivity of the European ancestor and the constitutional adaptability of the Zebu can be established. Then there is our own experience in the uplands of Ceylon where the descendants of cattle imported by the early tea planters bred under conditions which are not ideal and often subjected to the evils of exploitation by the low-country dairyman are not very mean performers as dairy cows. Finally there is the question whether crossing for the sake of the first cross only is not a sound economic proposition.

This catalogue of unsolved or partially-investigated problems presents a very extensive field for experimental work, and it is proposed to carry out this work at Bopatalawa. Climatically the site has been well selected, because the simulation of the conditions of the temperate zone is as approximate as it is possible to get in Ceylon, and, if the poverty of the available pasture is overcome by its replacement with new varieties of grass or neutralized by the introduction of other equivalent forms of feeding, there is every reason to hope that a herd of European cattle not far removed from the original type either in constitution or in productivity will be established. Adequate data are not available to enable one to say which European breed will adapt itself most readily to the conditions at Bopatalawa. Dr. French, the management of the Hope Farm in Jamaica, and the Escola Superior de Agricultura e Veterinaria de Minas Gerais, Brazil, appear to have found the Friesian to be most suitable for their experiments in cross-breeding. But

Dr. French himself in his present article expresses the view that "probably the smaller or more-slowly-maturing European breeds will prove the best". In these circumstances it seems to be advisable to try out a number of breeds—say, the Friesian, the Ayrshire, and the Jersey—simultaneously. Perhaps the Department should not wait till it has finally decided which of these breeds is best suited to Ceylon before it starts its crossing trials. A programme may be drawn up at once providing for the maintenance of several groups with different proportions of Friesian (for it seems advisable to base these preliminary trials on the recorded experience elsewhere), and tropical blood. When the optimum proportion has been determined, animals of that grade may be bred together so as to fix the characteristics of a new type on the same principle as that on which the Southdown breed of sheep was evolved.

COCONUT CULTIVATION IN THE ISLAND OF TRINIDAD, BRITISH WEST INDIES

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GENETICIST, COCONUT RESEARCH SCHEME

COCONUTS have been grown in Trinidad since the 18th century, but there is no doubt that they were present in self-sown groves on the south-western littoral of that island in much earlier times. It is known that the palm existed in the South-American continent, in Venezuela and in the Chilean Andes, before it appeared in Trinidad; and the theory has been put forward that the currents of the Orinoco flowing into the sea carried with them floating coconuts which lodged and sprouted on the Cedros beaches under the most favourable conditions for germination and growth. It is quite unlikely that at that time any human agency was active in the cultivation of the palm and, indeed, even as late as 1836 no mention is made of coconuts or coconut products in the agricultural statistics of the Island. It is known, however, that at that time the inhabitants made an alcoholic drink with the fermented water of the coconut, an art which has been independently discovered by the people of the rural areas of the low-country of Ceylon, and that coir-fibre was used for upholstery, stuffing saddles and the manufacture of coarse ropes and cables. A certain amount of coconut oil was also used in the preparation of food.

Trinidad coconuts may be considered to have definitely entered the trade in 1863 when 226,791 nuts were exported. By 1875, this number had risen to 2,978,218 and by 1881, it exceeded 6 millions. The nuts were exported in the husk and were utilized mainly as dunnage between hogsheads of sugar shipped to England. They were later carried as top cargoes in vessels carrying asphalt. In England, the nuts were utilized for the manufacture of oil and fibre, which latter being vermin-proof fetched high prices; so much so, that mattresses stuffed with coir-fibre sold at a higher price than horse-hair mattresses. Whole nuts were sent in small quantities to the United States also, but as at that time there was no fibre-extracting machinery in New York, Philadelphia and neighbouring towns, the cost of husking by hand was so high that in the early '80s Trinidad merchants ceased to ship whole nuts to the United States of America.

At about the same time, a visitor to the Island drew attention to the anomaly of importing coconut oil from England to Trinidad, and on inquiry it was found that oil produced in Trinidad was actually dearer at Port-of-Spain than oil imported from England. More extensive coconut cultivation was therefore urged, the statement being made, rather hyperbolically, that a fortune could be made from the fibre quite apart from the kernel of the nut, which was becoming an important source of vegetable oil.

In those days, the coconut palm in Trinidad was almost entirely a forest crop, self-sown, densely crowded and completely uncared for. As stated earlier, there were groves of coconuts on the Cedros beaches and there was also a belt on the West Coast in the Cocal; and just as the currents of the Orinoco were regarded as responsible for the entry of coconuts into Cedros, so it was conjectured that the belt of palms in the Cocal had arisen from a scattered cargo of nuts which had been swept up on the beaches from a drifting wreck. Patches of palms were also found to the south of the Cocal, in the Nariva-Mayaro region and on the north coast up to Galera Point.

During the last quarter of the last century and at the beginning of the present century, the demand for vegetable oils in European markets increased rapidly and investors turned their attention to the cultivation of coconuts on a plantation scale in contrast to regarding the palm as a convenient and profitable forest crop; but West Indian sugar was already an important industry and sugar cane, by reason of its being easier to grow and quicker in giving returns, very nearly ousted the coconut even in regions where it had become naturally established. Thus the Cedros area, with about 60 inches of annual rainfall, abundant sunshine, and deep, black, sandy loams—conditions naturally ideal for coconuts—was also most suitable for sugar cane; but cane planters soon found themselves handicapped for want of labour and by the difficulty and cost of transportation, and by 1910 almost all the sugar plantations in Cedros were planted up with coconuts. In 1910, the areas under coconuts in Trinidad and Tobago was given as 20,000 acres. In 1918, the area in Trinidad alone had increased to 27,000 acres, Cedros and Mayaro together accounting for 16,300 acres, producing 33 million nuts a year, and some 2,000 acres in young plantations. There were three oil factories in Mayaro district producing annually 100,000 gallons of oil and 500,000 lb. of poonac which was consumed locally. A contemporary report states, "Great confidence in the future of coconut planting appears to exist in Trinidad, and coconut planting is carried on by sugar and cocoa planters".

Up to the year 1920, it could be said that the majority of coconut plantations were situated on ideal coconut land, only

a few being on heavy, badly-drained soils ; but up to that year the agricultural wealth of Trinidad was carried on the shoulders of the cocoa and sugar growers, coconuts being no more than a minor crop. In 1920 there was a slump in cocoa and growers were faced with ruin, with the result that many of them cut down their cocoa and replanted their land with coconuts, such land often being heavy, sticky and badly drained and thus thoroughly unsuitable for the palm. Similarly, the slump in sugar resulted in considerable areas of heavy cane land also being planted up with coconuts. These later plantings brought up the acreage to over 30,000 in 1921.

By the end of the first quarter of this century the area under coconuts in Trinidad consisted of,

1. The Cocal on the east coast, a strip seldom more than a few hundred yards wide, but many miles long, where the palm was a more or less self-sown and reproducing forest crop, growing under very favourable conditions due to the natural fertilization of the soil by the seepage into the sea of the waters from the Nariva Swamp, almost completely uncared for and irregularly spaced at the rate of 80–90 palms per acre or more. The annual rainfall in this area was about 80 inches and the annual yield was often as much as 5,000 nuts per acre.

2. The Nariva-Mayaro region, south of the Cocal, to a point where the sandy coastal flats disappeared ; not less fertile than the Cocal owing to similar conditions of soil and climate and not less productive.

3. The North Coast district where conditions were less favourable to coconut cultivation, but where the crop was made to pay by good management. Here too the land was naturally fertilized by seepage water from the hills. Coconuts were also found in sheltered bays on the North Coast and on the marine terrace in the north eastern region, a natural formation from 100 to 120 yards wide and 100 feet above sea-level. Here the soil was mostly loose sand and mixed with humus.

4. Cedros, the most suitable coconut district in Trinidad, where soil and climate were ideal for maximum production and where annual yields of over 5,000 nuts per acre were recorded on some estates. Here too there are patches of heavy soil on which the palm does not thrive so well, but estates on such land were efficiently managed, large sums being spent on drainage and cultivation which enabled the palm to be grown profitably.

5. Plantations in other parts of Trinidad, which had replaced cocoa and sugar-cane or which were planted on virgin land mostly unsuitable for coconuts by reason of the soil being heavy and difficult to drain.

Fig. 1.—Coconuts as a forest crop in Trinidad ; over-crowded irregularly and too closely spaced, self-sown and with a rank undergrowth of weeds. This and the subsequent photographs were taken by the author in February and March, 1940.

Fig. 2.—Coconuts planted on edges of sugar-cane beds, too closely spaced and with half their root systems in water. Note the large number of fallen nuts.

A writer in 1926 suggested that the history of coconut planting in Trinidad could be divided into three stages in which,

1. The most suitable land was planted or self-planted.

2. Cultivation was extended to unsuitable land owing to pressure of population and rise in market prices coupled with increased facilities for ocean transportation. At the time, the industry was said to be entering into this second stage.

3. Owing to economic pressure there would be a general retreat of cultivation from the poorer lands and increased production in the better areas by intensive methods of agriculture. He stated "This third stage is not near at hand in Trinidad ; and the sharp increases in price are as dangerous and unsettling as sharp decreases, since they stimulate the planting of coconuts on low-grade land and therefore retard in such regions as Trinidad the trend toward a closer adjustment to geographic conditions".

That was in 1926. In 1940, when the present writer visited Trinidad, this retreat was well advanced but increasing economic pressure was only one of its causes. Two other causes, equal in potency to economic pressure, have been faulty agriculture and disease ; and disease is closely related to bad agriculture as the latter is no doubt to some extent related to economic pressure.

A report published in 1906 states that in opening up land under coconuts in Trinidad, little or no attempt was made to utilize selected planting material, that in some cases seed nuts were indiscriminately imported from Venezuela and other countries, that little tillage or manuring was done, that nuts were planted at stake which prevented any selection of seedlings as normally carried out in nurseries, that the planting distance was only 25 feet and that the palms under such conditions did not come into bearing until they were 12 to 20 years old. It is stated that, owing to inefficient methods of agriculture, some plantations were already going off even in 1906.

Later plantings were apparently done more carefully or on better land, because in 1910 it is reported that palms in certain areas were coming into bearing in 4 or 5 years and reaching economic production in 12 to 14 years. An annual production of 100 nuts per palm in such areas is given, but one is inclined to doubt this figure as the planting distance is stated as being 15 to 18 feet, which would result in a stand of 151 to 193 palms to the acre, which is on an average three or four times as many as are planted in Ceylon.

It has been stated already that in 1921 the area under coconuts was estimated as exceeding 30,000 acres. This had increased to 45,000 acres by 1930, which year could perhaps be regarded as marking the beginning of the retreat mentioned earlier.

The faulty practice of agriculture and a number of ambient influences form a mutually reactive system. These are an erratic demand for the product which is often bound up with an uncertain supply, violently fluctuating prices at the large buying centres with their disastrous effects on local markets, distance from markets and lack of transport facilities, a misunderstanding of the requirements of the crop, lack or meagreness of capital and credit facilities, scarcity, high cost, inefficiency and/or inefficient utilization of labour, lack of adequate mechanization of cultural operations, lack of cheap power for operating machinery, outbreaks of pests and diseases and, finally, lethargic, spasmodic and badly-informed State supervision.

Tropical agriculture as a whole has suffered from some or all of these causes since its organization into plantation units and Trinidad has had, perhaps, more than her fair share of trouble. In the early days of coconut cultivation, when little attention was paid to scientific agriculture, an erratic demand was closely bound up with an uncertain supply; but with the appearance of plantations this latter uncertainty was largely removed and a growing recognition of the importance of vegetable oils in soap and margarine manufacture resulted in an increased and increasing demand for copra and coconut oil. The entry of other vegetable oils, such as palm oil, and of hydrogenated fish oils, notably whale oil, did not greatly alter this demand, but it did bring about a scaling down of prices. This in itself would not have been a serious matter and would in fact have resulted in a stabilization of prices to the mutual benefit of all producers of oil, but soap and margarine manufacture fell into the hands of big business corporations, which also had control over whaling operations, and it was not long before whale oil was used as a stick with which to beat the producers of vegetable oils. It was found possible by the simple expedient of extending or contracting whaling operations to control the prices of vegetable oils to the advantage of the manufacturers.

Trinidad came in for her full share of trouble due to violent price fluctuations, but to the good fortune of the coconut industry there happened to be oil mills in the country capable of crushing all the copra that was produced and, furthermore, the local demand for coconut oil was such that there was no necessity to ship any of it to Europe or the United States. The oil maufacturers, some of whom also happened to be growers, were not slow to take advantage of this extremely happy combination of events and in 1930 the Government was persuaded to introduce protective legislation directed at encouraging the local manufacture of coconut oil and lard substitutes. Tariff protection was given to the oil factories, the consumer was

Fig. 1.—" Cutlassing " weeds, the universal form of weeding, here seen practised in a grapefruit orchard.

Fig. 2.—" Cutlassing " nuts in the husk.

protected by the fixing of a maximum price for oil and oil products and the producer was safeguarded by the maintenance of a minimum price for copra.

Advantage was taken by the coconut growers themselves of this tariff protection given to oil manufacturers and in 1936 a number of them combined to form the Trinidad Coconut Growers' Association, which by the end of that year had a membership of 69 and had control of nearly 50 per cent. of the coconut production of Trinidad and Tobago. By 1938 this Association had erected a factory equipped with modern machinery for the production of edible oil and lard compound, and in 1940 arrangements were being made to instal a margarine plant.

Thus, it will be seen that the possibility of a deterrent effect on coconut cultivation in Trinidad caused by an erratic demand in European and American markets and by violent price fluctuations in these markets has been removed or, at least, greatly mitigated by wise action on the part of the Government and by co-operation among manufacturers and growers; and this same protection and co-operation have taken the Trinidad coconut industry out of the sphere of stagnation due to curtailment of transport facilities in times of war, such as these, which have struck a crippling blow at coconut producers in countries like New Guinea, the Malay States and in the Far East generally and those engaged in the oil palm industry in the Dutch East Indies and Africa.

The faulty practice of agriculture, which is often brought about by erratic demand, instability of prices and transport difficulties, is greatly aggravated by an insufficient understanding of the cultural, manurial and general environmental requirements of the crop; and this is mostly in evidence when businessmen take to agriculture with the sole purpose of turning crops into cash. In Ceylon, it was possible, by a lucky accident, to convert derelict coffee land in the higher altitudes into first-rate tea plantations with a minimum knowledge of the ecological requirements of tea, but when heavy cane and cocoa lands in Trinidad were converted into coconut plantations, a blunder of the first magnitude was committed from the evil effects of which the island has not yet recovered. But, quite apart from this extension of cultivation to unsuitable soils resulting in some cases in an almost irremediable state of malnutrition of the palms, the manurial and cultural requirements of the crop even on the more suitable soils have been inadequately satisfied, and the general debility and unproductiveness of the palms on most estates and their consequent susceptibility to disease are mainly due to what might be termed remediable malnutrition.

The old type of sugar cane cultivation, or cane-farming as it is called in the West Indies, was not the best school for a training in agriculture nor the best demonstration of agricultural methods for those engaged in the cultivation of perennial crops like cocoa and coconuts, or for those turning to these crops as an escape from the depression in sugar. Nothing could be more primitive and inefficient than the old methods, still practised on some sugar estates, of bad planting, over-ratooning and under-manuring, and there is no doubt that these same practices have led to the exhaustion of the soil of many plantations and even of whole islands in the West Indies. With slave labour in the early days and poorly-paid indentured East Indian and emancipated negro labour in more recent times, coupled with returns of nearly £100 gross income per acre with sugar selling at £80 a ton, it was possible to continue in the old ways and shut one's eyes to the gradual depletion and general ruination of the soil; and coconut planters could learn little or nothing from the gentleman-farmers on sugar plantations in the palmy days of the sugar industry.

The coconut palm in Trinidad, having begun as a reproducing forest crop, has remained more or less in this primitive state even where active extension of cultivation has been adopted. Coconut lands are almost completely innocent of the plough, the harrow and even the humble mamoty. As for manuring, the planters either depend on the bounty of Providence and expect seepage waters from neighbouring swamps in their exit to the sea to fertilize the land or misunderstand their problems to the extent that they are more ready to ascribe the debility and gradual death of thousands of palms to some obscure and vaguely defined "physiological disease" than to pause and consider whether the palms are not really suffering from under-nourishment and neglect of soil management.

The most common and in fact the only form of cultivation adopted on the majority of estates is "cutlassing" (or "slashing" as it is called in Ceylon and the Malay States) whereby the rank growth of weeds is infrequently and at irregular intervals cut down by a type of scythe called a cutlass and left lying on the ground to dry and decay. The soil is not opened up and aerated, no thorough weeding is done in the sense of digging up the weeds by the roots or turning them into the soil, no green manuring, no adequate draining, no removal of dead palms nor observation of the generally accepted principles of plant sanitation. Here again, Providence has been kind to the Trinidad coconut growers. The black beetle, *Oryctes rhinoceros*, L., is not found there, but the possibility of a chance introduction of this pest should not be ignored.

Examples of faulty soil management are to be seen everywhere in Trinidad and many such came to my notice during the short time that I spent there. For instance, to take an extract at random from my diary, I find that on March 7, 1940, I was taken by an officer attached to the Department of Agriculture "to see a small plantation which he told me was in its fifth planting in 70 or 80 years. This lay by the coast along the main road from Port-of-Spain to St. Pierre, past the Pan-American Airways Port. The area was permanently waterlogged and the soil was therefore peaty and black in colour. An excellent growth of grass was noticed among the coconuts. The young palms were said to grow well and bear heavily till about the 20th year and then die. I myself saw palms, that could not have been more than eight years old, carrying heavy bunches of nuts, and other palms, which appeared to me to be well over twenty years old but which my companion assured me were not older than twenty years, showing signs of senility both in the stem and in the crown.

No cultivation of any sort was done on these lands and the palms were planted very close to each other. In some cases, the distance between them could not have been more than 10 feet.

Going on, we came to higher ground where palms were planted on slopes and more or less inter-planted with limes. Both palms and limes were dying or dead. My companion said that the cause of death was the same in both cases, *viz.*, the restricted root range owing to the impervious nature of the soil. Pruning the limes, he told me, gave them a further short lease of life, but sooner or later they died.

I was told that no manuring or cultivation was done, and as far as I could see, death was due to this as much as to any other cause. The soils are undoubtedly difficult, but they are made worse by continued neglect".

In the former case, where the soil was very rich by reason of its position by the sea, it was obvious that what the land required was drainage and wider planting; but I was told that the owner of the property found it quite profitable to replant every 15 years or so in the same old way and did not think it worth his while to resort to drainage and correct spacing of palms. This may have been so in a country where cost of labour was said to be very high, but it appeared to me to be a most wasteful practice.

Later in the same month (Sunday, the 17th) I visited Guayaguayare Bay and Mayaro Bay and made the following entry in my diary:—

"The coconuts in these regions are growing under almost complete forest conditions. The planting distance varies from

nil (where from two to six palms are growing in the same clump) to not more than 18 feet between palms. All stages of growth are to be found together, from seedlings a few months old to palms of 40 years and up to what appeared to me like 60–70 year old palms. They all appeared to be self-sown and I noticed no attempts at planting. Perhaps a few have been planted by hand, but it has been done so haphazardly that they are hardly noticeable. The shade is so dense that there is hardly any other undergrowth, but it is plain that this same shade interferes with the normal growth of the palms and their productions of nuts. No attempts at cultivation were seen and it is likely that the seepage from the Nariva Swamp is sufficient to keep the soil supplied with nutrients without resorting to artificial manuring. The palms looked quite healthy and I noticed no Bronze Leaf Wilt. Production could probably be more than doubled by thinning out the plantation and planting up vacancies on a systematic scale."

Two days later I was on my way to Cedros with the same Agricultural Officer as had on a former occasion pointed out to me the Trinidad method of planting coconuts in swampy soils, and this trip is recorded in my diary as follows :—

"We passed various coconut areas on indifferent and poor soils, mostly low-lying and clayey. Mr. X. pointed out an area near Longdenville where coconut trunks were lying on the ground and the land being got ready for cane. This area which was said to have a sandy topsoil 5 feet deep overlying clay had been recommended by a visitor to Trinidad as being good for coconuts, as similar land in Ceylon was, according to him, put to the same use. Coconuts had been planted and had grown for 18–22 years and had then died of Bronze Leaf Wilt. No attention had been paid to the soil or to the palms ; neither manuring nor cultivation.

A little further on we came to an area of coconuts which had been poisoned with sodium arsenite to make way for cane. Later we passed an area of coconuts interplanted with limes. The latter were alive but the former had died owing, it was said, to the hardness and imperviousness of the soil, but to a greater extent, in my opinion, due to neglect. The limes were also going off.

A Red Ring patch was pointed out to me some distance away and I was told that as no control measures were being attempted the disease was slowly infecting the neighbouring areas."

Trinidad provides an outstanding example of what might be termed "speculative agriculture". In Ceylon, it will be remembered that during the big rubber boom quite a few land-owners cut down mature coconuts in order to plant rubber

Fig. 1.—Gouging the kernels from the thirds of the nuts. The possibility of contamination with sand and dirt is plainly visible.

Fig. 2.—Covered barbecue. The galvanized iron roof is movable.

and when the slump came rubber in its turn was cut down for replacement with coconuts. But it must be said for the Ceylon estate owner that in the process of changing over from one crop to another, a wholesale sweep was made of the offending crop before the other was planted. No attempt was made to interplant rubber with coconuts or coconuts with rubber in effecting the change-over.

In Trinidad, speculative agriculture has been practised on a larger scale—cane to coconuts, cane to cocoa, cocoa to cane, coconuts to cane and at the present time coconuts and cocoa to tonka beans ; and in making the great change-over from cane to coconuts, instead of completely removing the cane and replanting the land with coconuts or at least planting the coconuts in the centre of the cane beds making proper allowance for correct spacing, the coconut seedlings were planted on the edges of the 20-foot cane beds with 25 feet between seedlings in the beds with the cane still standing. This resulted in the coconut seedlings being too close together with most of their roots in the more or less water-saturated soil in the drains between the cane beds. The early growth of these seedlings must have been very good owing to their still narrow root range, but by the time they had formed stems and the canes had to be removed, their roots must have been permanently in water and a state of physiological drought must have set in with a consequent incidence of Bronze Leaf Wilt. Many old cane plantations replanted with coconuts in this manner are to be seen in Trinidad and now some of them on which the coconuts have proved unprofitable are having their dead and dying palms removed to make way for a return to cane-farming.

It must not be inferred from the examples given above that all coconut plantations in Trinidad are in the same state. There are notable exceptions and these are to be found mainly in the Cedros district, but even in that region plantation management cannot be regarded as being up to the best practices in Ceylon. To take an example at random, one evil attendant on cutlassing was seen on a plantation where a thick mat of tinder-dry weeds had caught fire by accident or design. The flames had been so fierce that some fine young palms which made up the block were badly burned and the toil and expense of many years thus thrown away in one night. Such fires were said to be not infrequent and discontented labour was suspected of being responsible for them. No change in cultivation practice was, however, contemplated as a check on such incendiarism.

It is not intended in this essay to make more than passing mention of the difficulties encountered by Trinidad coconut growers due to the lack or meagreness of capital and credit

facilities. In the days of slave labour and easy access to land there could not have been the same scarcity of capital as a natural aptitude and training among agriculturists and "emancipation only meant the substitution of a low wage for the previous outlay on the purchase and maintenance of slaves, besides absolving employers from responsibility". In later times no doubt there was much money to be spent and sometimes wasted on speculative agriculture and many expensive mistakes must have been made by the pioneers as for instance in the fruitless attempts made to grow sugar cane instead of coconuts in the Cedros area and coconuts instead of cocoa and sugar cane in the interior of the island. In 1913 owners were willing to spend and were spending up to £40 an acre on development of land under coconuts and one estate of 500 acres in the Cedros district had actually spent £18,143 for that purpose. This rate of spending was confined to a few estates and was no doubt reduced during slump years; but on the other hand, incomes were good and estate owners could have had no great cause for complaint at least up to the year 1929, when the post-war economic structure of Europe and America finally collapsed. Thus one estate, 1,300 acres in extent, made during the years 1919 to 1929, a nett income of £20,000 a year or £15 per acre, *i.e.*, about Rs. 200 per acre.

The depression since 1929, coupled with labour costs, have made things very difficult for estate owners but they have at least achieved the supreme triumph of co-operation which has been mentioned earlier and which will be treated in greater detail in a subsequent paper; and it is not too much to hope that this same co-operation will help greatly in bringing about a general stabilization of the industry in the future, provided it is saved from distruction due to other causes to be mentioned later.

At the present time, male labourers on coconut estates in Trinidad are paid up to 2 shillings a day and female labourers generally half that sum, although it often happens that daily earnings amount to rather more than these sums, since a fair amount of estate work is done on the task system. Although these wage rates are generally considered too low for decent living it is, on the other hand, pointed out by the estate owners that even at these rates it is difficult both to compete in the world's market with producing countries where wages are lower and at the same time to adopt intensive methods of agriculture involving regular cultivation and manuring and measures of general plant sanitation.

In many instances hot air driers and covered barbecues are used in the manufacture of copra. But the finished product, whether sun-dried or dried in hot air kilns is of poor quality in

Fig. 1.—Trinidad copra. Note extensive mould-growth.

Fig. 2.—Bronze leaf wilt.

comparison with Ceylon copra. All the samples seen by the writer were covered with moulds. The fault is to be found in the initial preparation of the nuts for drying. As a rule, the husk of the nut is not removed before the nut is opened unless the nuts are to be sold in the shell. Instead, the whole nut is directly cut into three segments by a cutlass, the blade passing right through the husk, shell and kernel. The thirds of the nuts are then handed over to women who gouge out the fresh kernel which is often broken into small pieces in the process. Cutlassing nuts is done either by men or by women and paid for by the task.

All this work is carried out in the field or on grass or sand near the kilns; and it will be plain that the broken pieces of kernel become contaminated with sand and dirt and expose a large surface to infection by bacteria and moulds.

The only copra that is dried in the shell is obtained from culls rejected during the grading of husked nuts, quite a considerable quantity of which is still shipped in that state. Thus all those nuts that pass through a $3\frac{3}{4}$ inch ring are used for copra curing.

The nuts themselves should be very suitable for copra-making as picking is done only two or three times a year, which results in the presence of large numbers of naturally fallen nuts at most times of the year, but, as a matter of fact, on many plantations collection is not regularly carried out, owing to which a large percentage of sprouted nuts are used for copra making, with a consequent decrease in the weight of copra obtainable as well as in considerable damage to its appearance. On one estate the writer saw a heap of nuts collected from the field for cutlassing in which there were some with sprouts 18 inches long. These nuts must have been on the ground for 6 to 7 months.

No doubt mouldy copra and copra from sprouted nuts are not rejected by oil millers owing to the high percentage of oil generally found in such copra, but it cannot possibly pay the producers to release these inferior grades on the market. The loss in weight must be very considerable.

In Trinidad, besides Phytophthora Bud Rot against which there are no known preventive or curative measures, the two most important diseases of the coconut palm are Red Ring and Bronze Leaf Wilt. Red Ring, the most obvious symptoms of which are a red streaking of the ground tissues of the leaf-stalks and the presence of a red or reddish ring of tissue between the vascular bundles of the stem, is caused by the eel-worm, *Aphelenchus cocophilus* Cobb., which may invade the palm by way of the roots, the stem or the leaf bases of the crown. As

a rule only four to seven-year old palms are affected, younger or older palms being attacked only infrequently. Affected palms, almost without exception, succumb to the disease and these dead palms can serve as sources of infection to surrounding healthy palms. The eel-worms are said to be able to pass from palm to palm through the soil and one method of control is based on this belief. It has also been conjectured that they are able to travel up the surface of the trunks and gain entry into the palm by way of cracks in the leaf bases. The most recent theory is that the eel-worms are carried by the fauna that are normally associated with coconut plantations, such as various insects, tarantulas, spiders and rodents. It has also been suggested that the Black Vulture (*Coragyps atratus foetens* Lichtenstein), whose diet includes bits of coconut kernel, which are left lying about under the palms after the nuts have been split and gouged, might be attracted to diseased palms which have been felled and later carry the eel-worms on its feet to the crowns of healthy palms.

Whatever the mode of infection may be, one significant fact that has emerged from the study of the disease is that it is almost absent on lands where sugar cane is grown as a catch crop among the coconuts for any period up to eight years. Sugar cane cannot be grown under forest conditions. It has to be tilled, manured and weeded ; and there is no doubt that the coconuts under these conditions derive some benefit from the cultural treatments given to the cane. It is also conjectured that during the process of weeding the cane a secondary host of the eel-worm is removed, although such a host has not yet been discovered. On account of these observations and theories the old method of control of Red Ring by means of isolation trenches round the palms is now not wholeheartedly recommended. Instead, the latest methods of control have been laid down as follows :—

> " All weeds round palms which are three years old should be dug out for a distance of 5 feet from the trunk, the soil being cultivated, and a liberal dressing of complete artificial fertilizers given. The amount and ratio of the mixture would vary with different soils, but a dressing suggested is 5 lb. per palm of a mixture of 4 cwt. sulphate of ammonia, 2 cwt. of sulphate of potash and 4 cwt. of superphosphate of lime. Except on light sandy soil, where 50 per cent. more sulphate of potash would be required, this would certainly stimulate the young palms to more rapid growth, and in at least a number of cases would effectively change the flora on the treated soil. The same treatment should be given annually for a period of four years. Apart from any influence which it might very reasonably have on the incidence of

Red Ring disease the treatment should fully repay expenditure by bringing the palms into crop some years before those not receiving the cultivation and manuring ".

At the present time, Red Ring has become relatively unimportant in Trinidad owing to the appearance of the far more formidable malady known as Bronze Leaf Wilt.

In 1924, it was observed that many coconut palms were dying of a disease in which the outward symptoms were a yellowing and wilting of the outer leaves, a browning of the unopened inflorescences and the shedding of young nuts. The bud was not affected in the early stages of the disease, but all palms that showed signs of wilting in combination with the other symptoms mentioned died sooner or later. In 1925, a similar disease was observed in British Guiana and there too the bud tissue was the last to be affected. By 1928, thousands of palms in Trinidad were seen to be affected, and a special study of the disease was begun. Two types of wilt were recognized (1) where the symptoms were similar to those of a root disease described in Ceylon as due to the fungus *Macrophomina phaseoli* and (2) where no fungus was found in the roots, but death was ascribed to a state of physiological drought, *i.e.*, a condition in which the palm was unable to take up water from the soil. This latter disease was named Bronze Leaf Wilt owing to a bronzing of the foliage during the process of wilting. The symptoms of the disease have been described as follows :—

" The three lowest leaves of bearing palms, which usually appear quite normal and healthy previously, are observed to have taken on a yellow and bronze colouring, the colour proceeding from the tips of the leaflets backwards. At the same time the tips of the next two or three leaves are seen to be yellowing, the extent of discoloration increasing with increase in the age of the leaf. The yellowing of the leaf extends up to still younger leaves but long before the youngest leaves show discoloration of any kind a rot sets in at the base and in the folds of the leaflets of the central spear of leaves. The rot later extends into the cabbage. This rot develops to a considerable degree before the central spear of leaves changes colour but in the later stages of the rot they wilt, turning to a dull greyish-brown colour and fall over at the base. Shedding of nuts takes place at the same time or slightly in advance of the discoloration of the leaves, the youngest nuts being shed first. The oldest inflorescence on the tree is seen to be changing to a brown colour, in some cases even before the spathe has opened."

It was found that the disease could be artificially induced by cutting trenches round a healthy palm and thus inhibiting water uptake and that in some cases a diseased palm could be

cured by the simple process of watering. The disease was found to be most prevalent on heavy soils in bad tilth, where palms were overcrowded on the land; and it was, therefore, suggested that Bronze Leaf Wilt could be prevented by soil cultivation, drainage, proper spacing of palms and periodical removal of weeds, a combination of cultural operations which, with manuring, is usually regarded as elementary in efficient coconut cultivation. Investigations were continued in 1929 and the observations of the previous years were confirmed and the same recommendations were repeated. In 1930, Bronze Leaf Wilt was found in the neighbouring island of Tobago, prevalent under the same conditions as in Trinidad; and was seen to have made headway on the stiff, clay soil of the coastal belt of British Guiana. In the latter place, groups of palms were seen to wilt as opposed to the wilting of individual palms scattered here and there. Again an unsuitable environment and faulty cultural practices were given as the first causes of the disease.

These suggestions regarding the causes of the disease found general acceptance, and, in the administration report for 1930 of the Director of Agriculture of Trinidad and Tobago, it is categorically stated that Bronze Leaf Wilt was related to the extension of coconut cultivation to unsuitable soils. At the same time, soil chemists in Trinidad were discovering that manuring coconuts showed profitable increase of yield over unmanured areas and also over pre-manurial periods and an experiment was laid down to ascertain whether manuring had any effect on Bronze Leaf Wilt. The situation was by now sufficiently serious to warrant the institution of a Coconut Survey by the Department of Agriculture and in 1931 it was found that 400 out of 1,900 properties examined were affected by wilt. This was so alarming that it was considered necessary to re-examine the earlier observations on the disease and to make a more direct and careful study of it. Accordingly, in 1932, an experienced officer of the Department was appointed to carry out the necessary investigations, the Imperial College of Tropical Agriculture providing him with laboratory facilities.

It is interesting to note that in the same year, a wilt disease of coconut palms, similar to Bronze Leaf Wilt, was observed in Ceylon and in Jamaica. In Ceylon, the trouble appeared in the environs of Puttalam after a severe and protracted drought and was found to be worst on poorly-cultivated estates and on wet, swampy land and on soils liable to water-logging. As a preventive against the physiological condition, proper soil cultivation, improvement of tilth and drainage to induce deeper rooting were recommended. In Jamaica, wilt was found to occur in a locality which had experienced a serious

drought followed by excessive rain and was confined almost entirely to hill slopes with heavy clay soils. It was recalled that a wilting of palms under similar conditions had occurred in Jamaica in 1911 and 1912, and the important observation was made that the condition was reduced to insignificance by proper cultivation and drainage. Only palms weakened by abnormal weather conditions and growing on unsuitable soil were found to suffer.

At the commencement of the special inquiry instituted in Trinidad, the observations of earlier workers both in Trinidad and in other countries were once again confirmed, but it was found that although Bronze Leaf Wilt was worst on heavy soils, it was sometimes present on free-draining light soils also ; but it was not found on the sandy coastal belts around Cedros and in the Mayaro region.

The inquiry was concluded in 1937, and it was definitely confirmed that the disease occurred on all soils, ranging from the very sandy types to clays, but that the compactness of the soil and its perviousness to water were of primary importance in relation to it. Palms died from wilt on heavy soils liable to water-logging, on light, open-textured, free-draining soils, and on soils which had a layer of marl, a so-called " intolerant layer " underlying a friable top soil. All wilt soils showed a high content of nitrogen, but low phosphorus and potassium, especially the latter. The root-systems of all wilted palms examined were found to be limited by the high water-table in water-logged areas or by the intolerant layer when it was present close to the surface. In the water-logged areas, masses of rotted roots were seen below the level of the water-table, but where wilt was encountered in open-textured, free-draining soils, the wilted palms had better root systems than on the other two soil types but poorer root systems than those of healthy palms.

Thus, after five or six years of patient and intensive work, it was found that, in addition to the fact that no insect or fungus was primarily associated with the disease, coconuts were affected by Bronze Leaf Wilt on :—

1. Heavy clay soils, even when they were naturally rich in plant nutrients, unless they were adequately drained and aerated.

2. Light, sandy, free-working and self-draining soils, unless they were supplied with plant food, particularly potash, and unless measures were adopted to conserve soil moisture and,

3. Soils with an intolerant layer of marl, which for some obscure reason, refused to allow the coconut palm to grow and thrive.

On the first type of soil, draining was once again recommended. On the second type, manuring, especially with potassic fertilizers, the burial of husks, other organic matter and farmyard manure, irrigation and, on undulating land, contour draining. Where contour draining was found to be too expensive, a change-over from coconuts to Tonka Bean was recommended. On the third type of soil, a reversion to sugar cane was advised.

The situation in 1937 was described by the Director of Agriculture in his administration report as proving disastrous. In 1938, Bronze Leaf Wilt was still taking its toll of the palms. In the following year, no improvement is recorded and in 1940, when the writer visited Trinidad, the wilt situation on some estates was quite alarming and the disease was spreading.

Many names have been given to the disease, the most arresting of which is undoubtedly "Bronze Leaf Wilt." It has been ascribed to "physiological drought". It has been called a "nutritional-physiological malady" and a "physiological die-back". These names are self-explanatory and, if the causes of the disease have been correctly ascertained, as they no doubt have been, the coconut industry in Trinidad is faced with a serious decline, except in the sandy coastal belts and the Brasso Silts. Its resuscitation lies in the adoption of the recommendations made by the many investigators of the disease from time to time, which are, as stated earlier, based entirely on accepted principles of tropical agriculture. Except on the marls and heavy clays, which are by their very nature said to be unsuitable for coconut cultivation, Bronze Leaf Wilt should be regarded as a preventable and remediable condition. On the marls and the clays, sugar-cane can be and is grown with success. On the other soil types on which coconuts have been planted, it may not be possible to get the very high annual yields of 6,000 nuts per acre obtained in the coastal areas, but under careful estate management it should be possible to secure profitable yields of 4,000 to 4,500 nuts per acre. The regular and judicious use of the plough and the disc-harrow from the time of transplantation, rigorous attention to weeding, water-conservation and drainage, scientific manuring (particularly potash manuring), replanting with selected nuts from high-yielding palms at a minimum planting distance of 28 feet on the square or its equivalent, the cultivation of cover crops and their correct utilization on the land, and husk trenching on the soils liable to rapid drying are cultural operations that have been practised with profitable results in older coconut growing countries; and there is no reason why their adoption should not prove beneficial under the conditions prevailing on coconut plantations in Trinidad.

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THE RELATIVE RESISTANCE OF SOME STRAINS OF BITTER-GOURD TO THE CUCURBIT FRUIT-FLY

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FRUIT-FLY (*Dacus cucurbitae* Coq.) has compelled the total abandoning of cucurbits in certain market-garden areas in Ceylon, and represents the most serious hazard in cucurbit growing in this country. The female fly pushes its ovipositor through the epidermis and deposits its eggs within the fruit. The larvae hatch out in about a week and cause extensive rotting of the fruit. When the larvae have attained their maximum size, they drop out of the fruit on to the ground, and pupate just below ground level. Examination of the ground under rotting fruits will reveal considerable numbers of pupae. Flies eventually emerge from these pupae and effect re-infestation of the crop. The relatively short life cycle of the cucurbit fruit-fly leads to the rapid increase in fly numbers, and in consequent fruit damage, towards the close of the fruiting season. Despite its limited host range—only fruits of the family *Cucurbitaceae* are subject to attack—the survival level of the fly remains high in most instances and extensive infestation of successive crops results. Probably numerous wild gourds function as alternate hosts.

Apart from the regular collection and destruction of invaded fruits, the only remedial measure available to the grower has been the use of sodium silicofluoride baits. These baits are, however, of doubtful value. Fruit-flies feeding on these baits are reputed to fly away and die elsewhere ; there appears to be no evidence that the flies actually imbibe lethal quantities of the poison. Apart from the question of their efficacy the baits involve considerable and recurrent expenditure. As in the instance of other pests of village crops, the production of resistant varieties appears to be the only satisfactory solution to the fruit-fly problem.

The search for fruit-fly resistance in cucurbit varieties was initiated by Dr. J. C. Haigh, Botanist, when he established the three vegetable seed stations at Matale, Tabbowa and Karadiyanaru in 1937. Particularly promising results have been obtained with bitter-gourds (*Momordica charantia* Linn.). The present paper reports the results of yield and fruit-fly resistance tests of some strains of bitter-gourd carried out during the period, 1937–41.

The 1937–40 experiments.—Two varieties were originally selected for trial in 1937, *viz.*, the variety CD from the Central Division, and the variety, NWD white smooth, from the North-Western Division. The variety CD consisted of a mixture of types differing in shape and external colour of fruits. The "rough" types possessed pronounced, fragile ribs. Two distinct colour classes were distinguished, *viz.*, green and white. The variety CD was sorted in 1938 into the following component strains :—

1. CD green rough
2. CD green smooth
3. CD white rough
4. CD white smooth

Trials were set down by Dr. J. C. Haigh at the three vegetable seed stations, at Matale, Tabbowa and Karadiyanaru. Fruit-fly was severest at Matale and least damaging at Karadiyanaru in the relatively dry *yala* season. Records of fruit-fly incidence at Karadiyanaru and Tabbowa are scanty and are not included here. The high incidence of fruit-fly at Matale makes it an ideal centre for the isolation of resistant varieties. The station is located in the heart of an extensive and flourishing vegetable industry. The soil of which the main component is ironstone gravel, is, however, infertile and atypical.

At Matale, in the *maha* season, 1937–38, the variety CD heavily outyielded the variety NWD white smooth ; the yields of fruit in the varieties CD and NWD white smooth were 3,470 lb. and 655 lb. per acre respectively. The overwhelmingly superior performance of the variety CD is, in part, explained by its relatively greater resistance to fruit-fly attack ; the percentages of fruits destroyed by fruit-fly in this season, in the varieties CD and NWD white smooth, were 14 and 76 respectively.

Records of fruit-fly incidence and of yield for subsequent seasons, after the sub-division of the variety CD into its component strains, are given in Table 1. The figures refer to 1/10-acre plots. The analysis of variance of percentages of fruit-fly damage, converted to the appropriate inverse sine scale ($\theta = \text{Sin} \sqrt[-1]{p}$), is given in Table 2. In this analysis, the effect of seasons is confounded with replicates. The variance ratio for strains attains significance at the one per cent. point. Examination of individual strain means indicates the significant superiority of all the CD strains to NWD white smooth.

It is evident from Table 1. that, apart from their higher degree of resistance to fruit-fly, the CD strains are markedly superior in the yield of both numbers and weights of fruits. CD green rough outyielded the other CD strains.

The maha 1940–41 experiment.—In the *maha* season, 1940–41 the four CD strains and the strain NWD white smooth were again tested out at the Vegetable Seed Station, Matale, in a randomized block lay-out comprising four replications of 1/44-acre plots. Hills were spaced 4 × 4 ft. Four seeds were dibbled per hill on November 21, 1940 ; the resulting seedlings were thinned first to two, and eventually to one per hill. Blanks were supplied. The final stand was satisfactory. Five-weeks-old plants were trained to supports. The only troublesome pest, apart from fruit-fly, was the *Aulacophora* beetle. Plants were sprayed with lead arsenate ($\frac{1}{2}$ oz. per gall.) on the day the beetle was first noticed. The plants flowered 5–6 weeks after sowing. Fruit-fly was first observed on January 20, 1941. Daily records of fruit-fiy damage were kept till the completion of the harvest. In the harvests, a single border row of plants was discarded round each plot. The fruits were picked during the period January 29–March 1. Records were maintained of the total numbers of fruits produced and of the numbers and weights of sound fruits.

The analysis of variance of percentages of fly-damaged fruits transformed to the inverse sine scale ($\theta = \text{Sin} \sqrt{p}$), is given in Table 3. The variance ratio for strains exceeds the 5 per cent. point and indicates significance. Strain totals of the transformed data and their standard error are given at the foot of the table. Every one of the CD strains is seen to be significantly more resistant then the strain NWD white smooth. None of the CD strains, however, differ significantly in resistance from one another.

The analysis of variance of weights of sound fruits produced is given in Table 4. The variance ratio for strains attains significance at the 5 per cent. point. Examination of individual strain totals by means of their standard error reveals the significant superiority of all CD strains, except CD green smooth, to the strain NWD white smooth. CD green rough significantly outyielded CD green smooth. The differences between the other CD strains are not significant.

The analysis of variance of numbers of sound fruits is given in Table 5. The variance ratio for strains exceeds the 5 per cent. point, and is hence indicative of significant effects. In the examination of individual strain totals with the use of their standard error, all the CD strains, except CD green smooth, are seen to be significantly superior to NWD white smooth. The CD strains do not differ significantly from one another.

The analysis of variance of total numbers of fruits produced—these figures include, of course, the fruits destroyed by fruit-fly—is presented in Table 6. The variance ratio for strains is significant at the 5 per cent. point. The tests of individual strain totals with the use of their standard error, demonstrate the significant superiority of all CD strains, except CD green smooth, to NWD white smooth. It is evident that the superior performance of the CD strains, green rough, white rough and white smooth, is not completely accounted for by their greater resistance to fruit-fly attack ; these strains are intrinsically more prolific than NWD white smooth. CD green smooth is significantly inferior to CD green rough and CD white rough.

The strain CD green rough has put up the most consistently satisfactory performance both in respect of yield and of resistance to fruit-fly during the whole experimental period, 1938–1941. Further selection for yield and for fruit-fly resistance will accordingly proceed within this strain It is encouraging to note that the continuous selfing envisaged in this programme of selection would not lead to loss in vigour. Cucurbits, unlike most other naturally cross-pollinated crops, are not injuriously affected by continuous inbreeding.

Examination of the records over the whole experimental period reveals indications of a narrowing down of the differences in fruit-fly susceptibility between the various strains. This apparent reduction in resistance in the CD strain, or the apparent grading up of the strain NWD white smooth, may find an explanation in the considerable natural crossing that must have occurred in the field.

SUMMARY

Five strains of bitter-gourd (*Momordica charantia* Linn.), *viz.*, four strains, CD green rough, CD green smooth, CD white rough and CD white smooth, from the Central Division, and a strain, NWD white smooth from the North-Western Division, were tested out for yield and for resistance to the cucurbit fruit-fly (*Dacus cucurbitae* Coq.) at the Vegetable Seed Station, Matale, during the period, 1938–41.

2. The four CD strains exhibited, in all experimental seasons, a higher degree of resistance to fruit-fly than the strain NWD white smooth. The four CD strains did not differ significantly from one another.

3. In the *maha* season 1940–41 the strains, CD green rough and CD white rough, proved to be significantly superior to the strain NWD white smooth in the yield of both numbers and weights of sound fruits. CD white smooth yielded a significantly larger number of sound fruits than NWD white smooth, and CD green rough a significantly greater weight of sound fruits than CD green smooth.

4. In the *maha* 1940–41 experiment it was evident that the strains, CD green rough, CD white rough and CD white smooth, apart from their greater resistance to fruit-fly, were intrinsically more prolific than NWD white smooth, *i.e.*, the total number of fruits produced by these CD strains was significantly larger. The strains, CD white rough and CD green rough also significantly outyielded CD green smooth in the total number of fruits.

5. The strain CD green rough was consistently the best performer in regard both to resistance to fruit-fly and to yield.

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TABLE 1.—Records of yield and of fruit-fly incidence, 1938–40

Strain.	Season.	Yield of Fruits. No.	Yield of Fruits. Wt. in lb.	Percentages of Fly-damaged Fruits.
CD green rough	maha 1938–39	1742	165½	11
	yala 1939	2723	395	15
	maha 1939–40	3946	483	4
CD green smooth	maha 1938–39	1307	138	12
	yala 1939	2123	353	16
	maha 1939–40	2178	250	10
CD white rough	maha 1938–39	1735	168½	12
	yala 1939	2385	355	16
	maha 1939–40	2457	259½	9
CD white smooth	maha 1938–39	353	37	39
	yala 1939	1434	218	25
	maha 1939–40	1594	169	8
NWD white smooth	maha 1938–39	134	20½	71
	yala 1939	587	149	55
	maha 1939–40	1139	237	23

TABLE 2.—Analysis of Variance of Percentages of Fly-damaged Fruits Transformed to the Inverse Sine Scale ($\theta = \text{Sin} - \sqrt{p}$)

	DF.	SS.	MS.	VR.	1 per cent. point.	0.1 per cent. point.
Strains	4	1429·78	357·445	9·53	7·01	14·39
Seasons	2	477·80				
Error	8	300·03	37·504			
Total	14	2207·61				

Summary of Results

	CD green rough.	CD green smooth.	CD white rough.	CD white smooth.	NWD white smooth.	S. E.
Degrees	17·9	20·8	20·5	28·3	44·7	± 3·54
Percentages	9·4	12·6	12·3	22·4	49·5	

TABLE 3.—Analysis of Variance of Percentages of Fly-damaged Fruits Transformed to the Inverse Sine Scale ($\theta = \text{Sin}-\sqrt[4]{p}$)

	DS.	SS.	MS.	VR	5 per cent. point.	1 per cent. point.
Blocks	3	62·11				
Strains	4	382·07	95·52	5·14	3·26	5·41
Error	12	223·04	18·59			
Total	19	667·22				

Summary of Results

	CD green rough.	CD green smooth.	CD white rough.	CD white smooth.	NWD white smooth.	S. E.
Degrees	38·7	42·0	43·3	44·3	51·9	±2·156
Percentages	39·2	44·8	47·0	48·8	62·0	

TABLE 4.—Analysis of Variance of Weights of Sound Fruits

	DF.	SS.	MS.	VR.	5 per cent. point.	1 per cent. point.
Blocks	3	872·5				
Strains	4	2651·4	662·85	3·52	3·26	5·41
Error	12	2258·4	188·2			
Total	19	5782·3				

Summary of Results

Yield.	CD green rough.	CD green smooth.	CD white rough.	CD white smooth.	NWD white smooth.	Significant Difference.
Lb. per 4/41 acre	308·5	210·0	267·0	231·5	175·0	84·5
Lb. per acre	31621·3	21525·0	27367·5	23728·8	17937·5	8661·3

TABLE 5.—Analysis of Variance of Numbers of Sound Fruits

	DF.	SS.	MS.	VR.	5 per cent. point.	1 per cent. point.
Blocks	3	45577·2				
Strains	4	179871·5	44967·875	4·81	3·26	5·41
Error	12	112167·3	9347·275			
Total	19	337616·0				

Summary of Results

	CD green rough.	CD green smooth.	CD white rough.	CD white smooth.	NWD white smooth.	Significant Difference.
Number of sound fruits per 4/41 acre	2191	1604	1868	1683	1034	596
Number of sound fruits per acre	22458	16441	19147	17251	10599	6109

TABLE 6.—Analysis of Variance of Total Numbers of Fruits

	DF.	SS.	MS.	VR.	5 per cent. point.	1 per cent. point.
Blocks	3	72080·95				
Strains	4	139036·30	34759·075	4·61	3·26	5·41
Error	12	90435·30	7536·275			
Total	19	301552·55				

Summary of Results

	CD green rough.	CD green smooth.	CD white rough.	CD white smooth.	NWD white smooth.	Significant Difference.
Number of fruits per 4/41 acre	3558	2873	3489	3254	2713	535
Number of fruits per acre	36470	29448	35762	33354	27808	5484

A NOTE ON SOME PRELIMINARY COLD STORAGE INVESTIGATIONS RELATING TO CEYLON FRUITS

Exd.

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COLD storage investigations relating to Ceylon fruits were started in 1937 in co-operation with the New Colombo Ice Co., Ltd., who made available for these trials the necessary cold storage facilities and rendered all assistance possible. The object of these investigations was to work out the storage life of Ceylon fruits, with a view to determining the possibilities in regard to their commercial storage and transport. The investigations relate to the following fruits: mango, mangosteen, grapefruit, orange, mandarin, avocado pear, papaw, sapodilla, pineapple, custard apple, soursop, cherimoyer, and bael.

Three series of trials were carried out. The first in 1937–38 was mainly exploratory and confined to four varieties of fruit—grapefruit, mangosteen, avocado pear, and mango. The second, conducted in 1939, was rather more elaborate in scope and detail and had for its object the determination of the "commercial storage life" of the fruits under trial. By this term is meant the length of time the fruits can be stored before spoilage from fungal rots and functional diseases is 10 per cent. (1). The varieties of fruit experimented with were: orange, pineapple, sapodilla, custard apple, cherimoyer, and bael fruit.

The third series of trials conducted in 1940 was designed to ascertain the storage behaviour of varieties of local fruit at different temperatures during a period of four weeks, and how they would react when transferred subsequently to temperatures of 80°F (the normal Colombo air temperature) and 65°F (the average English summer temperature) respectively. The following fruits were under experiment: mango (5 varieties), grapefruit (2 varieties), orange, mangosteen, mandarin, soursop,

papaw, and avocado pear. For various reasons, however, the original programme could only have been adhered to in the case of the orange and mangosteen trials.

The fruit for the trials was obtained from Departmental Stations or reliable growers. Great care was taken in their selection. Only sound, well-matured fruit was chosen. On arrival at the cold store the fruit was sorted out and placed in open trays in the storage chambers. These were maintained at temperatures ranging from 35° to 55°F.

The results of observations are summarized under each fruit separately. In every case the storage period specified refers to the " commercial storage life " of the fruit variety under test.

MANGO

The varieties experimented with were: Willard, Jaffna, Vellai Columban, Karuthai Columban, and Ambalavi. The fruits were obtained from Jaffna except in the case of the Jaffna variety, which was obtained from Colombo. They were fully-grown and well-matured but hard. The number of fruit for each test generally varied from 20 to 100, and the storage temperatures from 40° to 50°F. Willard stored well at 45–50°F for a period of about three weeks. Jaffna stored best at 45°F for about three weeks. Vellai Columban kept well for three weeks at 50°F, but the Karuthai Columban and Ambalavi varieties gave best results at 40°F, the storage life being in each instance three weeks. In the earlier series of trials, the flavour and appearance of the Willards were quite good even after a storage of seven weeks at 40°F. These trials indicate that the optimum storage temperatures for most local varieties of mangoes range from 40° to 45°F, and that the commercial storage life is about three weeks.

MANGOSTEEN

Mangosteens were stored at 40°, 45°, and 50°F respectively. One hundred fruits were kept under observation in each lot. The fruits were picked at the stage when, though fully-grown, they were of a pale pink colour. In cold storage they changed to the dark purple colour of the ripe mangosteen. The fruit stored at 40°F had a commercial storage life of about a fortnight. After four weeks, when 50 per cent. of the fruit had spoilt, the sound fruits were divided into two lots and transferred to temperatures of 80° and 65°F respectively. All were spoilt within five days. The fruit at 45°F stored well for more than three weeks. At the end of four weeks, 27 per cent. had gone bad. The remainder, removed to temperatures of 80° and 65°F respectively, were spoilt within five days. At 50°F the fruit had a storage life of two and a half weeks. At the end of

four weeks, the sound fruit (66 per cent. of the original number) were transferred to 65° and 80°F, but were all spoilt within four days. The rinds of spoilt fruits were generally very hard and of a dull brown colour. Under atmospheric conditions mangosteens have a commercial storage life of about a week's duration.

It will thus be noted that 45°–50°F is a suitable temperature range for the storage and transport of local mangosteen, the commercial storage life being about three weeks. In these trials, losses up to 34 per cent. of the fruit occurred during a period of four weeks, and the remainder were all spoilt during five days storage at both 65° and 80°F. Earlier observations indicated that a temperature of 42°F was not unsuitable for the storage and transport of local mangosteens. The results of experimental shipments of mangosteens from Burma to the United Kingdom, showed that 50°F was the optimium storage temperature for this fruit. Successful transport was, however, dependent on other conditions *viz.*, freedom of fruit from disease, correct degree of maturity, *i.e.*, an "almost ripe" stage, and the method of packing (2).

GRAPEFRUIT

The earlier trials were confined to the two varieties—Walters and Cecily Seedless. The storage temperatures were 40°, 45° or 50°F. It was then observed that the fruit stored well for about eight weeks. The second series of trials was carried out with the Walters and Marsh's Seedless varieties. The number of fruit for each test was 50. These trials indicated that the optimum storage temperature for Walters grapefruit was 40°F and for Marsh's Seedless 45°F. At the end of a period of five weeks at 45°F only 4 per cent. of the Marsh's Seedless fruit had been spoilt. Of the remainder, 20 per cent. were spoilt after one week's storage at both 65° and 80°F. Walters showed a spoilage of 27 per cent. at the end of nine weeks' storage at 40°F. The subsequent spoilage percentages of sound fruit during one week's storage at 65° and 80°F were 20 and 25 per cent. respectively.

ORANGE

Oranges from Bibile were stored at the temperatures 35°, 40° and 45°F, the number of fruit in each lot being 30. It was noted that the commercial storage life was about seven weeks at the optimum temperature of 35°F. Subsequent trials with lots of 50 each of the local green orange showed that 40° and 45°F are suitable temperatures for the storage of this variety. At the end of four weeks storage at these temperatures, only 4 per cent. of the fruit were spoilt. Of the remainder over 50 per cent. went bad during one week's storage at both 65° and 80°F.

MANDARIN

Beauty of Glen, Emperor, and Nagpur varieties from Pelwehera Station were stored at 40° and 45°F. The number of fruits under observation in each lot was 75. The fruit kept well for four weeks at both these temperatures.

SAPODILLA

Fifty sapodilla fruits were stored at each of the temperatures 40°, 45°, and 50°F. From the commercial standpoint, the fruit stored well for a week at 40° and 45°F.

PINEAPPLE

Kew pineapples were stored at 45°, 50°, and 55°F. Sixteen fruits were kept under observation in each lot. The fruit stored well for six weeks at each temperature. Later trials gave very disappointing results largely because the fruit had been affected by some disease due to the wet conditions prevailing during growth.

CUSTARD APPLE

Custard apple was stored at 45°F and 50°F. Twenty-five fruits were used for each test. The fruit stored best at 50°F, the commercial life being just over two weeks.

SOURSOP

Soursop was stored at 45° and 50°F. Twenty-four fruits were kept under observation for each test. The fruit stored best at 45°F, the commercial storage life being three weeks.

CHERIMOYER

Cherimoyer fruit were stored at 50°F and 45°F. The number of fruits in each lot averaged fifteen. The fruit kept well for over two weeks at 45°F.

PAPAW

Papaw was stored at 40°F, 45°F, and 55°F. The optimum storage temperatures were 50°–55°F, but the commercial storage life was only two weeks.

AVOCADO PEAR

The earlier tests with the St. Anne variety of avocado pear appeared to indicate that from two to three weeks was the longest period the fruit could be stored, 40° F being the optimum storage temperature. Subsequent trials with the local variety of avocado pear showed that of the fruit stored at 40°, 45° and 50°F, those at 40°–45°F kept best, but the commercial storage life was only one week.

BAEL (AEGLE MARMELOS)

Bael fruit was stored at 45° and 50°F. Thirty-two fruits were stored at each temperature. The fruits stored best at 45°F, the commercial storage life being eight weeks.

MEAN AND MAXIMUM STORAGE LIFE

In the second and third series of the trials referred to above, in addition to the "commercial storage life", data were obtained of the "mean storage life" *i.e.* the period when 50 per cent. of the fruit were spoilt, and the maximum duration of storage (100 per cent. spoilage) of the different varieties of fruit under test at the optimum storage temperatures. As the data may be of some interest, they are given in Table I.

GENERAL DISCUSSION

As a result of these trials it may be concluded that the only local fruits of any importance which offer possibilities in regard to commercial storage and transport abroad are the mango, mangosteen, citrus varieties and some types of pineapple. Of the minor fruits bael is the most promising. It will also be noted that the commercial storage life of certain local fruits is appreciably shorter than what has been obtained with the same fruit in other countries (1, 3). The citrus varieties in the West Indies and Alphonso mangoes in India are examples in point. In the case of citrus varieties, the relatively short storage life observed in these tests is due to the quality of the fruits which had been adversely affected by the prolonged droughts of 1939 and 1940.

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TABLE I.

Fruit	Variety	Mean storage life (50 per cent. spoilage)	Maximum storage life (100 per cent. spoilage)
1. Mango ..	Willard ..	Between 3 and 4 weeks.	About 4 weeks
	Jaffna ..	do. ..	do.
	Ambalavi ..	About 3 weeks ..	do.
	Karuthai Columban ..	„ 4 „ ..	About 5 weeks
	Vellai Columban	„ 4 „ ..	„ 5 „
2. Orange ..	Bibile local ..	Two months ..	About 10 weeks
	Local green ..	6 to 7 weeks ..	do.
3. Grapefruit ..	Walters ..	> 9 weeks ..	„ 10 „
	Marshs ..	> 8 „ ..	„ 10 „
4. Mandarin ..	Beauty of Glen, Nagpur, Emperor	Between 4 and 5 weeks	
5. Pineapple ..	Kew ..	About 7 weeks ..	8 weeks
6. Mangosteen ..	— ..	> 4 weeks ..	About 6 weeks
7. Papaw ..	— ..	About 2 weeks ..	„ 3 „
8. Custard apple	— ..	„ 3 „ ..	„ 7 „
9. Cherimoyer ..	— ..	„ 3 „ ..	„ 4 „
10. Soursop ..	— ..	Between 3 and 4 weeks	„ 4 „
11. Avocado pear	Local & St. Anne	About 3 weeks ..	„ 4 „
12. Sapodilla ..	— ..	„ 3 „ ..	3 to 4 weeks
13. Bael ..	— ..	„ 9 „ ..	10 weeks

POISONING OF CATTLE BY ARTIFICIAL MANURES

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ALTHOUGH artificial manures are used largely on estates in Ceylon, cases of poisoning of cattle by such manures have been of very rare occurrence in the past. Some years ago a number of "tavalam" bulls on an up-country estate which had been transporting bags of a manure mixture died. The mixture in this case contained among other things calcium cyanamide and potassium nitrate. The bulls had been observed to lick the manure bags with relish apparently liking the salty taste of the mixture. The symptoms shown were suggestive of hydrocyanic acid poisoning and experiments in the laboratory showed that goats died with classical symptoms of hydrocyanic acid poisoning when drenched with a suspension in water of this mixture.

In a case recently reported, sixteen head of cattle died a short time after being allowed to graze on a portion of a rubber estate which had been dressed the previous day with nitrate of soda.

All sixteen cattle died within a few hours. The symptoms as described by the keepers were bloating, distress shown by the cattle running about wildly, severe purging with, in some cases, eversion of the rectum and bleeding.

On post-mortem examination by the Assistant Veterinary Surgeon, severe inflammation of the abomasum and small intestines was observed. Irritant poisoning was suspected and the Assistant Veterinary Surgeon collected about a cigarette-tin-ful of what he described as "a white powder which had been spread on the land" and sent it for examination. He also sent samples of stomach contents from the dead cattle. These productions were examined by the Agricultural Chemist who reported—

(*a*) That "the white powder" was nitrate of soda in the granular form which is less hygroscopic than the amorphous form.

(*b*) That the stomach contents were negative for arsenic and other heavy metals and for hydrocyanic acid, but gave a marked reaction to the test for nitrates.

A guinea pig which was drenched with approximately 2 grammes of the white powder in solution in the evening was found dead on the following morning and on post-mortem examination showed inflammation of the small intestines.

The Assistant Veterinary Surgeon reported that a search of the area over which the cattle had been grazing failed to disclose any known poisonous plants.

On this evidence there can be little doubt that "the white powder" namely granular nitrate of soda had been responsible for the death of the cattle.

Several interesting points arise from this incident.

In the first place nitrate of soda is commonly used as a manure in Ceylon yet no cases of poisoning by it have been reported in the past. A search of the literature available was made but no records of poisoning by nitrate of soda could be found.

Cases of poisoning of cattle by nitrate of potash are recorded in the literature, such cases having occurred where nitrate of potash has been given as a purgative in mistake for Epsom salts. In these cases the dose of nitrate of potash had been from ½ to 1 lb. in solution in water.

As a rule the sodium salts are less toxic than the corresponding potassium salts which would lead one to assume that the fatal dose of nitrate of soda would probably be round about half a pound. If that assumption be correct, the affected cattle must have consumed a considerable quantity of the manure. This is quite possible as nitrate of soda has a not unpleasant slightly salty "cool" flavour. It is well known that cattle often show a marked craving for salt and will lick salt with avidity if occasion offers. It is quite possible that this is the explanation of this unusual occurrence.

Another point is that had the amorphous and very hygroscopic form of nitrate of soda been used it is most probable that all or most of it would have gone into solution and been absorbed into the soil in the interval between the application of the manure to the soil and the cattle being allowed to graze over the land.

The unusual features of this incident are that the substance incriminated is one very commonly used as a manure and one which is not poisonous unless taken in comparatively large quantities.

The combination of circumstances which brought about this accident are dry weather, the fact that a very short time elapsed between the manure being applied and the cattle being

allowed to graze over the land, and, one must assume, that the cattle in this case had a definite craving for salt which led them to seek out and lick up this substance on account of its salty taste.

It is obvious that such accidents can be prevented by the very simple precaution of not allowing cattle to graze over land which has been dressed with nitrate of soda until an interval of some days has elapsed especially in dry weather.

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SELECTED ARTICLES

THE SELECTION AND PROPAGATION OF LIMES*

DURING the past year or two the planting of limes has been undertaken on a considerable scale in many parts of Jamaica, and there are signs that this movement to increase the island's output of limes is becoming more and more widespread. Large increases in the crop may, therefore, be expected within the next five years.

This development raises the question as to what means are to be employed to dispose of future crops. Of the three main outlets for limes, fresh fruit, lime oil, and lime juice, only the first seems capable of any large and rapid expansion ; for the production of lime oil is already tending to outstrip demand while the manufacture of lime juice has always been a rather doubtful proposition. It would appear desirable, therefore, that growers wishing to plant further limes should do so with a view to producing fruit suitable for the fresh fruit market.

At the present time the United States takes the bulk of the Jamaican green lime crop, but although this market is still expanding from year to year, the pressure of competition from other countries, especially Mexico, as well as from those limes produced in Florida, is also becoming increasingly severe. Of the other markets to which Jamaican limes are shipped the most important is the United Kingdom. Exports to this market have risen steadily during the past three years, but the only fruits taken in any quantity have been those of the larger sizes and the proportion of the crop disposed of in England will remain comparatively small so long as the average size of the fruit produced here remains as its present small dimensions. In order that this potentially very large market may be developed to the fullest possible extent it would seem desirable for growers to make every effort to increase the size of their fruits in future crops. Any improvement in this direction will have the additional advantage that it will reduce the proportion of limes rejected as too small even to ship to the United States or Canada.

In the case of established trees size and quality of fruit may be improved to some extent by cultivation, manuring and irrigation, but it is not the purpose of these notes to discuss these methods, but rather to show how growers can improve matters when planting new areas of trees. The points discussed are variation in lime trees and methods of selection and propagation.

VARIATION OF LIMES

The idea seems to be prevalent in Jamaica that the West Indian or Mexican lime is a more or less uniform and stable strain and that variations in the

* By G. K. Argles. Extract from the *Journal of the Jamaican Agricultural Society*, October 1938.

vigour, size of fruit and other characters are due solely to differences in soil, water supply, altitude, shade, and manurial and cultural treatments. While it is true that these factors do affect lime trees very markedly, it is, however, a fundamental mistake to imagine that the West Indian lime is in any sense of the word a horticultural variety.* Examination of any plantation of trees or of a row of seedlings in a nursery shows that we have a collection of varieties to be considered. Some trees are vigorous, others weak, some fairly upright, others spreading ; some are spiny, others nearly spineless ; and while some are scarcely affected by withertip others are seriously diseased. The size and shape of the leaves and fruit also vary greatly. Differences in soil and climate may accentuate or modify certain of these variations, but they cannot eliminate them, and under any given set of soil and climatic conditions we cannot depend upon two trees behaving in exactly the same way.

These variations among limes have arisen because, at any rate until recently, the lime has been entirely a wild tree crop and the only means by which it was propagated was the indiscriminate scattering of seed. Where seed is the means employed for multiplying a species differences are bound to occur between some of the progeny. The expression " some of the progeny " is used instead of " all of the progeny," because, unlike most tree crops, citrus species produce a high proportion of seedlings that are true to type. This happens through the occurrence of a phenomenon known as polyembryony, and were it not for this factor it is possible that the mixture of types in limes would by now be so great as to make an export trade impossible.

By polyembryony it is meant that the seed contains a number of embryos instead of one, and that all of these embryos except one are of vegetative origin and will develop like buds into trees identical to the female parent. The remaining embryo is of sexual origin, that is it arises as a result of pollination and fertilization, and will develop into a tree genetically different from its female parent. When germinating, lime seeds may thus often give rise to more than one plant per seed, and, as the vegetative embryos are usually more vigorous than the sexual embryo, the latter is commonly killed and only occasionally survives to form a tree. This explains why on some properties small groups of lime trees may be found all of which exhibit the same set of distinct characteristics. Despite this, perhaps one in every twenty or thirty lime trees growing wild arises from a sexual embryo and, differing in greater or less degree from its parent tree, will give rise to new groups of trees.

A second probable cause of variation lies in the marked tendency of citrus trees to produce bud mutations or " sports ". Many growers may have noticed lime trees bearing branches or fruits that differ in some respect from the other branches or fruits on the same tree. Seeds from fruits produced in this way give rise to plants that resemble the mutant form and not the original type. The great majority of these " sports " are of inferior quality, but it may be of interest to recall that certain of the well known citrus varieties, such as the Washington Navel orange, arose in this way.

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* The species to which West Indian limes belong. *Citrus aurantifolia* does contain certain clonal varieties such as the Persian seedless lime and the T1 lime, but none of these is of the true West Indian type. The T1 is a hybrid of inferior quality.

THE SELECTION OF LIMES FOR PROPAGATION

The foregoing remarks on variation in limes serve to emphasize that whatever method of propagation is to be used careful selection of parent trees is desirable. The characteristics upon which this selection should be based are as follows :—

(1) *Size of fruit.*—For reasons already stated large size of fruit is desirable, provided of course that the fruit is of good quality.

(2) *Shape of fruit.*—A roundish bell-shaped fruit is to be preferred to a long lemon-shaped fruit or to a round orange-shaped fruit. The widest section of the fruit should be situated towards the apex rather than in the centre. In other words the fruit should taper slightly towards the stem end, although without showing any bottle neck such as commonly occurs in lemons. A persistent stigma at the apical end is an undesirable feature of certain limes, since it is liable to be damaged in handling leaving a small exposed wound.

(3) *Quality of fruit.*—The main features here are a thin, smooth skin, plenty of juice of good flavour, few seeds, and a rich, deep green colour.

(4) *Tree shape and vigour.*—These are not always easy to judge in trees growing in bush or under shade, but where possible preference should be given to trees that are vigorous and relatively upright in habit of growth.

(5) *Freedom from disease.*—The most serious disease affecting West Indian limes is withertip or Anthracnose, caused by the fungus *Gloeosporium Limetticolum.* It produces a die-back of young shoots and leaves, destroys many blossoms and young fruits, and appears on mature fruits in the form of unsightly corky spots. Another common disease of limes in Jamaica is the Knot disease, caused by the fungus *Sphaeropsis tumefaciens.* This disease is also easily recognized by the large swollen knots produced on branches and shoots. In selecting trees for propagation preference should always be given to trees that are free from these and other diseases. This is advisable because limes undoubtedly vary in their susceptibility to different disorders. In fact there is one lime, the hybrid T1, that is known to be immune to withertip, but unfortunately the quality of its fruit is not sufficiently good to warrant its cultivation.

(6) *Spininess.*—Preference should be given to trees with a few short spines or, where possible, with no spines rather than to trees with numerous long spines. Pricks or scratches on the fruits provide points of entry for fruit-rotting organisms, and fruits found to be damaged in this way have to be rejected in the packing house.

In addition to the points mentioned above there is the very important consideration of keeping quality. A relatively short storage life is one of the main reasons why lime cannot compete more successfully with lemons in distant markets. This is, however, a problem that the grower is not in a position to study for himself, since cold storge facilities are necessary, but in selection work recently started by this Division it is a factor which will receive very careful attention.

PROPAGATION BY SEED

Seed is the simplest and commonest method of propagating lime trees, and, if the precautions described in this section are taken, there is no reason why this method should not produce as uniform a set of good trees as could other methods of propagation.

The first step is to select a satisfactory parent tree or trees, allow the fruits to ripen and then collect the seed. The usual citrus nursery practice of seed bed and nursery rows should then be followed, with the one important difference that steps should be taken to eliminate all sexually produced seedlings.

On germinating all seedlings which appear to differ in any way from the general run of plants should be removed. This includes all plants which are abnormally weak or vigorous or which showed distinct leaf or spine characters. Further roguing should be done in the nursery rows before the trees are planted in their permanent positions. In all it may be necessary to remove some 20 to 25 per cent. of the original stand of plants, but, if this is done carefully and systematically, the grower will have the satisfaction of knowing that all or the great majority of the plants remaining are of vegetative origin and should develop into trees showing the same set of characteristics as the parent tree from which be had taken the seed.

PROPAGATION BY BUDDING

The great majority of cultivated citrus trees are raised by budding the desired variety on to a rootstock, and of the species of citrus used for rootstocks preference has most commonly been given to the gummosis-resistant sour orange, *Citrus Aurantium*. Under certain climatic and soil conditions and with certain scion varieties, however, the sour orange has proved unsatisfactory as a stock and other species such as rough lemon, *C. Limonia*, sweet orange, *C. sinensis* and trifoliate orange, *Poncirus trifoliata* have had to be used in its stead.

Unfortunately experience of the behaviour of limes budded on to sour orange is limited to a comparatively small number of young trees, and it is impossible, as yet, to state with any degree of certainty whether or not the combination is likely to produce a healthy long-lived tree. In this connection it may be of interest to recount the experience of lemon growers in California. The lemon, although a distinct species from the lime, is its closest relative among the citrus fruits. Some 25 years ago almost all lemons in California were raised on sour orange stocks. For a number of years the trees grew and cropped well, but when they were about 20 years old many ceased growing, collapsed and died suddenly. Pomologists have attributed this sudden decline to incompatibility between the lemon and the sour orange arising out of the different physiological processes in the two plants. We do not know yet whether a similar fate will overtake lime trees worked on the sour orange, but the botanical relationship between the lime and the sour orange is just as remote as is the relationship between the lemon and the sour orange, and the possibility of failure cannot therefore be ruled out. Moreover there is apparently a tendency for some lime trees to snap off from the stock at the point of

union during windy periods, and this also suggests that the combination may not be wholly compatible. In these circumstances growers are recommended to discontinue budding limes on to sour orange until such time, some years hence, as more clear-cut evidence of behaviour has been obtained.*

Of the other rootstocks that might be used for limes even less is known. From the standpoint of closeness of relationship the rough lemon ought to prove the most successful, but even here failure might possibly occur owing to the differences in vigour between the two plants. The lime itself can of course be used as a rootstock, but this procedure does not offer any advantages over propagation by seed as described in the last section, nor apparently over propagation by means of cuttings as outlined in the next section.

In instances where growers may still wish to bud limes on to sour orange or other rootstocks the same rules apply to the selection of budwood as to the choice of parent trees for the production of seed. Particular care should be taken, after selecting a suitable tree or trees to avoid taking budwood from branches that have arisen as sports and are not true to the type chosen. Such sports are not necessarily distinguishable from the rest of the tree by foliage characters, but may often be recognized in the fruits. Thus in taking budwood preference should be given, where possible, to branches that are bearing one or more fruits of the desired shape and size.

PROPAGATION BY SEMI-HARDWOOD CUTTINGS

Propagation of limes by means of cuttings is still in an experimental stage, because, although we know that given suitable conditions limes can be easily raised in this manner, we do not yet know whether trees so propagated will develop as well, or live so long, as trees raised from seed. This method has however been chosen by us to raise a number of lime selections for the following reasons :

(1) Wood suitable for cuttings is available at almost all seasons of the year whereas ripe fruits are not always obtainable.
(2) Cuttings form trees somewhat more rapidly than do seeds.
(3) Seedless or almost seedless types can be included. These types could of course be raised by budding, but this method was ruled out on the grounds already stated and because of the risk that the reaction of the stock on the scion might mask the true behaviour of the scion varieties selected.

Several lime growers have intimated that they would like to try raising limes from cuttings and have asked for information as to a suitable technique. The following notes are based on the method we are using at present at the Low Temperature Station.

The first essential is a propagator, of which the most satisfactory type consists of concrete walls with glass frame cover. This is, however, expensive to construct, and a fairly satisfactory propagator can be made out of an old packing case with a cover consisting of " windowlite " (a form of cellophane with

* This recommendation does not of course apply to the budding of sweet oranges or grapefruit on to sour orange as both these combinations appear to grow satisfactorily.

fine mesh wire embedded). The cover should fit as closely as possible to produce high atmospheric humidity inside the propagator. High temperature is also desirable, and the propagator is therefore best placed in full sunlight, but the cuttings themselves should be protected from scorching by means of 2 or 3 layers of cheesecloth placed over the glass or " windowlite ". If there is either too much ventilation or too few layers of cheesecloth some or all of the cuttings will drop their leaves and thereafter fail to root.

The bottom of the propagator may be filled with coarse sand or gravel of any type to give proper drainage, but the medium in which the cuttings are actually placed should be chosen carefully. A fine sharp calcareous sand of the type found on many beaches, but free from salt, should give satisfactory results, especially if mixed with a little leaf mould or rich soil in the proportions 3 to 4 parts sand to 1 part leaf mould. If the sand used is too coarse the cuttings generally produce a lot of callus, but root only slowly if at all, whereas if the mixture contains too much soil they are liable to rot at the base. The rooting medium should consist of a layer 4 to 6 inches deep with the upper surface about 1 foot to 15 inches from the top of the propagator.

The cuttings themselves should consist of terminal flushes that have recently ceased to elongate and bear full-sized firm leaves up to the apex. With short flushes one cutting 4 to 6 inches long can be taken, but with longer flushes two or even three cuttings may be made from the one shoot. We use secateurs to remove the cuttings from the trees and for transportation purposes place them in damp moss. When ready to put them into the frame each cutting is pared back with a sharp knife to give a diagonal cut just below the base of a leaf stalk. Secateurs are not used for this operation because they tend to crush the wood slightly. None of the leaves are removed nor are they cut in half.

Once in the frame the cuttings should be watered at least twice a day. Given the right conditions rooting should start in 2 to 3 weeks and a majority of the cuttings should be rooting within 30 days. If care is taken in digging the cuttings up to see whether they are rooting no damage will be done.

After rooting has started the cuttings may either be left in the frames until considerable root growth has been made (say up to 35 days), after which all that are well rooted may be planted out and shaded for a few days, or they may be examined every few days and such as have just started to root be placed in pots containing a sandy soil, kept in the propagator for about a week and then hardened off in the pots put in shade and later in full sunlight before planting out. Cheap wicker work basket pots are very suitable for this purpose, since when the cuttings are ready to be planted out roots appear through the side of the pot, and, in setting out, both pot and plant are planted, thus producing no check to growth.

The rooted cuttings should be planted out in nursery rows fully exposed to the sun. Then, if the bed is never allowed to dry out completely in the early stages, shoot growth should start within a few days and trees large enough to transplant into the grove should be obtained in the space of 3 to 4 months.

THE FAILURE OF PURE AND HIGH-GRADE EUROPEAN CATTLE IN HOT CLIMATES*

DURING the last two years there has been a considerable increase in the literature dealing with the effects of climate on animal production. Many authors have discussed the reactions of European cattle in hot climates, and a brief discussion of this problem will be of value to stockowners in East Africa.

Local Zebu cattle are not sufficiently economic to satisfy the more intensive conditions of European farming, and the breeding and selection of improved local types is an expensive and life-long occupation. Most farmers therefore decide to get a much more rapid improvement by using bulls of recognized European breeds to grade up their Zebu stock. The Veterinary Department foresaw this trend of development and much time and money have been spent in experimentation. The results obtained have been discussed in the Annual Reports of the Veterinary Department for the last five years and summarized in the Empire Journal of Experimental Agriculture, Vol. 8, pp. 11–22, 1940.

Stated briefly, the results obtained were that half-grade animals were superior to the Zebu in every way. Higher grading towards a European breed invariably caused trouble, and the three-quarter and higher grades of cattle were definitely inferior to the half-grades and often less economic than the better Zebu types. The number of constitutional failures increased with higher grading to the European type, so that conformation as well as productivity left much to be desired.

Good types of high-producing animals have been imported to the Government farms, and a good measure of productivity has at first been obtained. Breeding trouble then occurred in a high percentage of cases, and the productivity in subsequent seasons has declined. In addition to this degeneration of imported stock, the first generation of stock born in this Territory were inferior to their imported ancestors. Subsequent generations declined still further unless fresh blood was continually imported.

It is interesting now to consider the reactions of farmers to this information because, generally, one of two attitudes is adopted. Either the farmer says, "Well, what else could one expect from Government activity", or he says, "Well, this may be true in Mpwapwa and Dar-es-Salaam but, on my farm where the climate and management, &c., are so much better, I am certain I could put up a good show". Actually, I have seen many constitutional failures amongst the high-grade stock of farmers and, in other case, farmers who realize they have graded too highly are using Zebu bulls to make their

* By M. H. French, M.A., Ph. D., Dip. Agric. (Cantab.), in *The East African Agricultural Journal*, Vol. VI., No. 4, April, 1941.

dairy herds more economic. The experience of the Government farms has been disregarded and many farmers are covering the same ground to their financial disadvantage.

The object of this article is therefore to show farmers that the same troubles are widespread throughout the tropical and sub-tropical areas of the world. It is not merely a Tanganyikan problem and the causes lie in the European breeds and their inability to adapt themselves adequately to an environment so dissimilar from that in which the breeds were originally developed.

Different breeds of animals, different systems of feeding and management, and different climatic conditions will obviously occur between Brazil, Texas, Louisiana, Jamaica, the Gold Coast, South Africa, Tanganyika, India, Queensland and the Philippine Islands, yet from these countries have come repeated statements that the grading up of local cattle with European bulls leads to constitutional failures. The level at which degenerative tendencies become obvious varies with the breed of animal, the climate and the management, but nowhere, so far, have high-grade European cattle adapted themselves completely to tropical climatic environments. This does not mean that European cattle cannot do extremely well inside the tropics if they live at an altitude at which the climate simulates that of temperate zones. Under such conditions, very little degeneration of type is observed, but once the animals are subjected to tropical and sub-tropical conditions their powers of adaptation become overtaxed.

That the poor development and retarded growth rates of young stock is not due to diets deficient in some essential constituent has been demonstrated in Brazil, Jamaica, India and Tanganyika. I have also shown recently that high-grade oxen can digest local foodstuffs just as efficiently as Zebus. With their larger stomach capacities, high-grade stock should therefore be just as capable of obtaining enough nutrients as the Zebu. Why, then, is it impossible to rear heavy-producing high-grade stock successfully in tropical environments ? The answer has not yet been worked out completely, but one factor of enormous importance has become generally recognized, *i.e.*, the inability of high-grade and pure-bread European cattle to eliminate heat sufficiently rapidly to maintain normal body temperatures.

It is perhaps only natural that the influence of high atmospheric temperatures should have been the first of the tropical climatic factors to be studied, because we all know the lassitude and lack of tone which follow a prolonged stay in a hot region. Most workers have recorded factors which are governed by the prevailing air temperatures, but it is well to remember that most of these are secondary to the effect of high air temperatures on heat elimination.

European breeds have been evolved under climatic conditions which necessitated the conservation of heat to maintain a normal body temperature. The Zebu, on the other hand, has been evolved under tropical and sub-tropical conditions where it has been more important to prevent overheating of the body. Naturally the European type will be less efficient than the Zebu in hot climates because its heat-regulating mechanisms will be functioning in a reverse and unfamiliar manner.

All body functions (eating, digestion, blood circulation, movement, and productive activities) develop heat. The larger, quicker-growing European animals produce greater quantities of heat than the smaller Zebus and so, not only are the European animals less able to eliminate heat than Zebus but they have more to dissipate if they are to maintain normal body temperatures. It is obvious that body temperatures can only remain normal if the rates of heat production and elimination are the same. Once the rate of elimination fails to keep pace with the rate of production, heat is stored in the body and the body temperature must rise.

This is exactly what happens in pure and high-grade cattle in high air temperatures, and the result is that these animals spend a considerable part of each day in a state of fever. Observations from all parts of the tropics and sub-tropics agree that the rectal temperatures of European and high-grade cattle reach high levels in the middle of the day and that this febrile state is prolonged for a considerable time after the air temperatures drop towards evening. The fact that the return to normal body temperature lags behind the evening decline in air temperature indicates that a large amount of heat is stored in the body during the day and that the rate of elimination is significantly lower than is desirable. With Zebu cattle there may be a slight increase in rectal temperature when grazing during the midday heat, but the increase is slight and quickly returns to normal as the air temperature drops. Certainly the Zebu does not reach a state of fever and must possess a better mechanism for heat elimination than European types.

It is well known that within any given breed certain individuals possess superior powers of adaptation to high external temperatures, but the variations between Zebu and European cattle are too great and too constant to be other than significant breed differences. The Zebu possesses superior powers of heat adaptation to the Aberdeen-Angus, Shorthorn, Sussex and Hereford breeds of beef cattle and to the Friesian and Ayrshire milk breeds. The different European breeds, however, are not all equally inferior to the Zebu ; for instance, the Friesian appears better able to withstand tropical conditions than the Ayrshire, and the Hereford better than the Aberdeen-Angus. The powers of adaptation of grade European × Zebu cattle lie between those of the parent types, but the higher the cross-breds are graded to the European type the less suited do they become to tropical conditions.

The body temperature of any animal is a measure of its efficiency to control heat elimination, and the failure of European animals to maintain normal rectal temperatures is therefore a clear indictment of their suitability to tropical climates. Much work has, however, been done to determine what causes European animals to lose their thermal control, and a brief summary of the chief heat-regulatory mechanisms will be given before proceeding to a discussion of the metabolic changes involved and their repercussions on other body functions.

Normally, hot-bodied animals lose heat to the surrounding atmosphere by radiation, but higher air temperatures reduce the rate of heat lost by this means and reserve mechanisms are then called into operation. In cattle, however,

the presence of a coat of long hair interferes with heat elimination, because a layer of air gets enmeshed in the long hairs and prevents the free exchange of heat between the skin and the air. With Zebu cattle the hair is short and fine and lies close to the skin, offering the minimum obstacle to free heat exchange. In European breeds the hairs are much longer and stand more erect, so that the free exchange of heat between their skins and the outside air is impeded. Here then is a genetical factor which tends to reduce the powers of heat elimination in European cattle as compared with Zebus.

Once the heat lost by radiation is insufficient to keep body temperature down, the body increases its blood circulation through the skin, so that the maximum amount of heat shall be lost by this physical process. With increasing air temperatures it is found that all breeds of cattle show increased pulse rates, but the increase is very much greater in European types than in Zebus. When the heart is forced to work extra hard for long periods each day it is liable to become overtaxed and lose its efficiency. This is very much more liable to occur in European than in Zebu cattle.

The next physiological process normally called into play, to allow heat elimination to keep pace with heat production, is sweating. By this mechanism a film of moisture is secreted on the skin, and by its evaporation a large amount of heat is dissipated. Unfortunately, cattle sweat very little and this avenue of heat elimination is of little significance, but experiments have shown that Zebu cattle have nearly twice as many sweat glands per unit of skin area as are found in the skins of European breeds. Here again, although the total effect is small, the Zebu have another genetical superiority over European breeds of cattle, and experiments have proved that the amount of water vaporized through the skins of Zebu cattle is one and a half to two times the amount transpired from European cattle as soon as the air temperature rises above the region of thermal neutrality for cattle.

Instead of sweating, cattle eliminate water vapour through the lungs to cool themselves. As temperatures rise every one must have noticed that cattle respire at increasing rates. Actually this provides the most spectacular difference between European and Zebu cattle, because, once the air temperature rises above 80° F., Zebus respire faster but the increase in respiration rates of European cattle is many times that of the Zebu increase.

Everyone is familiar with the spectacle of a mixed heard of European and Zebu animals out at pasture in the middle of the day, and must have noticed how the Zebus continue to graze long after the pure and high-grade European animals have sought the shelter of a shady tree. The Zebus continue grazing quite comfortably (with a slightly increased respiration rate) whilst only a few yards away European animals are standing in the shade (to get maximum surface cooling), panting at a very fast rate, often with their mouths open and saliva dripping from their jaws. This is a most convincing demonstration of the superiority of Zebus over European cattle in hot climates.

The failure to maintain body temperatures by European cattle in the tropics is therefore not due to a failure of the normal physiological processes which

promote heat elimination. In fact, these processes work at a much higher rate in European than in Zebu cattle, but still the rate of heat production outstrips the rate of elimination and body temperature rises.

As has been pointed out earlier, all body activities develop heat, and since the European breeds have genetic potentialities which allow them to grow quicker, and form flesh, fat and milk at higher rates than the Zebu, there is a greater heat production in European cattle than in Zebus. Even the eating, rumination and digestion of food generates an appreciable quantity of heat, and, since the larger European cattle need more food for maintenance purposes alone, it is obvious that they will always be at a disadvantage when compared with Zebus. It is this ability to convert larger amounts of food into flesh and milk, and the consequent more highly intensified metabolic system, which is probably the underlying cause of the failure of European cattle to adapt themselves completely to high air temperature. These breeds with their high metabolic capacity have been evolved in areas with low air temperatures for the greater part of the year and where heat elimination is not a serious problem. When they are introduced to areas where high atmospheric temperatures are the rule, the reduced rates of heat elimination cause distress and febrile conditions. This is in keeping with the fact that the smaller Jersey cows, with their lower food requirements for maintenance and consequently lower heat production, have proved the best European dairy breed for Jamaica and the Southern United States.*

What then will be the further effects of overheating the bodies of European cattle ? The first effect is the feeling of lassitude already mentioned, and probably the second is a reduction of appetite. With fever, appetite is never as high as when body temperature is normal and this lowered food intake will assist the distressed European cattle by reducing the quantity of heat generated from alimentation. On the other hand, a reduced food consumption means that less nutrients are available for productive purposes and the rates of growth, fattening and milk production will be lower than the genetic potentialities of the breed. This is in fact what has been observed in most parts of the tropical and sub-tropical regions. High-yielding milk cows can be imported and will do well for a period, but eventually their yields drop to much lower plane and, similarly, high grading to European bulls does not give corresponding increases in milk production.

Overheating also leads to high rates of water vapour elimination, and to counteract this desiccating tendency it is observed that European types of cattle drink much larger quantities of water than Zebus. The large water intake leads to a greater output of less concentrated urine and the kidneys are forced to work at a much greater rate.

It has also been shown that the haemoglobin index of the blood is reduced by rises in temperature and when the blood of Zebus is compared with that of

* It is likely that one factor in the Jersey's favour is a purely geometric effect of its small size. The ratio of surface (*i.e.*, both radiating area and sweating area) to weight decreases with greater total size and with increasing compactness of form. Thus a square heavy Shorthorn would have a lower proportion of surface to weight than an animal of a more leggy breed, and in general European cattle would in this respect compare unfavourably with the smaller, lighter built tropical breeds in their ability to keep the body temperature down.—*R.E.M.*

European cattle it is found that the latter have considerably lower haemoglobin and red cell counts, whereas in more temperate regions the haemoglobin index and red cell counts of European cattle are similar to those recorded for Zebus in the tropics. It is interesting in this connexion that the low haemoglobin index of European cattle in the tropics is not apparently caused by pathogenic agents and is also not relieved by feeding iron, copper and cobalt supplements at a high rate. There are also indications that high temperatures affect the alkalinity, salinity, non-protein nitrogen and sugar contents of the blood, but the importance of this is not clear. There may, however, be some correlation between the low haemoglobin content and the increased circulatory and respiratory rates. With the enormous increase in the two latter, a low haemoglobin is probably of importance in preventing over-oxygenation of the tissues.

There is an undoubted relationship between reproduction and overheating. It has already been pointed out that in imported European cattle breeding troubles occur and the fertility of pure and high-grade cattle is often very low. This problem has not yet been satisfactorily elucidated, but observations are reported showing that overheating in male animals seriously reduces the vitality of spermatozoa, inhibits spermatogenesis, and may even kill them if the body temperature rises to 106° F. Similarly, when European cows are brought in from grazings after midday, they have high body temperatures, and service at this time exposes the sperm to temperatures which may easily damage it. These two factors may therefore be partially responsible for the low conception rates in European cattle in tropical climates.

It has been mentioned above that European cattle can often be seen panting at a fast rate with saliva dripping from their open jaws. It has recently been reported from South Africa that when the body temperature rises to 106° F. in European cattle as much as four gallons of saliva have been collected from bulls out in the sun and as much as two gallons from animals in stalls. This means that there is a considerable loss (up to 2 oz. daily) of mineral salts drained from the body tissues.

A further complicating factor, introduced by the overheating of European cattle, which tends to start a vicious circle is the tremendous increase in the circulatory and respitatory rates. By increasing these rates considerably, the body is able to increase the rate of heat elimination, but they also involve a considerable increase in muscular activity. The latter inevitably results in an increased metabolism, which means that there is an extra quantity of heat generated. Also, as the heat-regulatory mechanism loses control and body temperatures rise, the normal metabolic reactions in the body become deranged and behave as uncontrolled chemical reactions where their velocity varies with the temperature. When this happens there is a considerable unnecessary liberation of heat at a time when heat elimination has already ceased to keep pace with production.

Once the velocity rates of the various biochemical reactions are accelerated by the increased body temperatures, the equilibrium points become shifted. The efficiency of the body then becomes reduced because, once a disturbance in one of the balanced bodily systems has occurred, repercussions of equal

magnitude will occur amongst the other systems of the complex. It is almost certain, for instance, that the endocrine balanced system would become disturbed and the results of this alone on various body functions would be enormous, and the same applies to the other complex biochemical systems on whose smooth running the wellbeing of the body depends.

Enough has probably been said to indicate the enormous importance of air temperatures in determining the degree of success that will follow the introduction of European types of cattle into areas possessing a tropical climate, but temperature is merely one factor in the environment. The influence of the sun and the humidity of the atmosphere are other factors exerting deleterious influences, and both factors exaggerate the effects caused by temperature alone. If this article has drawn the attention of farmers to this very important problem of breed reaction to environment it will have served its purpose. Improvement of Zebu cattle by grading up to European bulls is not merely a question of good feeding and management ; there are inherited characteristics in European animals which are working against their complete adaptation to tropical and sub-tropical environments. Some breeds, and these are usually the most improved of the European types, will fit less easily into tropical conditions than others. Farmers embarking on improvement schemes involving European cattle should give considerable thought to the breed they intend to use. Probably the smaller or more slowly maturing European breeds will prove the best.

Although this article stresse the bad results that follow the introduction of European animals, it must not be forgotten that a good measure of improvement will be obtained if the level of European blood in the progeny is kept down to half or less. Selection of better types of Zebu animals is obviously the ideal to aim at, but the time involved will usually make the farmer decide to try grading to a European bull. This will pay so long as the Zebu hardiness and acclimatization characters predominate in the progeny, and on Government farms in this Territory it has been found that animals higher graded than the half-breds are too weighted with European characters to be satisfactorily economic. At higher altitudes or where air temperatures are relatively low the level of grading, beyond which it is uneconomic to breed, will possibly be higher than the half-bred, but every farmer should test this for himself on a small number of animals before risking his whole herd.

It may be asked what should be done once the herd has reached the half-bred stage. There are two alternatives ; one is to use a native bull and, on the quarter grade progeny so obtained, use another European bull. Later crossing with native bulls will be needed to keep the level of European blood to half or less. This process is not very satisfactory because of the difficulty in obtaining Zebu bulls from a known milking strain, unless such animals are imported from India. The better alternative, I think, is to select a half-grade bull from a good cow and mate half-grade stock together. Although there may be great variation in type amongst the progeny, it should be possible by rigorous selection eventually to evolve a good strain of animal capable of producing milk or beef economically, but still remaining in harmony with the environment.

MEETINGS, CONFERENCES, &c.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD AT THE CEYLON CHAMBER OF COMMERCE ROOMS, COLOMBO, ON FRIDAY, APRIL 4, 1941, AT 2.30 P.M.

Present.—The Chairman (Mr. T. B. Panabokke, Adigar), the Financial Secretary (Hon. Mr. H. J. Huxham), the Chairman, Planters' Association of Ceylon (Mr. D. E. Hamilton), the Chairman, Ceylon Estates Proprietary Association (Mr. C. H. Bois), Messrs. J. D. Hoare, S. F. H. Perera, G. K. Newton, and Dr. R. V. Norris (Director and Secretary).

Mr. F. J. Whitehead was present by invitation.

1. The Notice calling the Meeting was read.
2. The Minutes of the meeting of the Board held on December 19, 1940, were confirmed.

Letters expressing regret at inability to attend were tabled from the Director of Agriculture (Mr. E. Rodrigo), Major J. W. Oldfield, Messrs. R. G. Coombe, and R. P. Gaddum.

3. MEMBERSHIP OF THE BOARD AND COMMITTEES

(i.) The Chairman welcomed Mr. D. E. Hamilton on becoming an Ex-officio Member of the Board on his election to the Chair of the Planters' Association of Ceylon and congratulated him on his election.

He also welcomed Mr. G. K. Newton, nominated by the Planters' Association of Ceylon to act for Mr. James Forbes on leave. (Letter dated December 17, 1940, from Secretary, Planters' Association of Ceylon).

(ii.) Reported that Mr. R. P. Gaddum had been nominated by the Ceylon Estates Proprietary Association to act for Mr. J. C. Kelly proceeding on leave. (Authority letter dated April 2, 1941, from the Secretary, Ceylon Estates Proprietary Association).

(iii.) The Chairman referred to the valuable help given by Mr. R. C. Scott, the late Chairman of the Planters' Association, both on the Board and the Finance Committee. A cordial vote of thanks to Mr. Scott for his services was recorded.

Finance Committee.—Proposed from the Chair that Mr. Gaddum be nominated to the Finance Committee to act for Mr. Kelly during his leave. Approved.

Estate and Experimental Sub-Committee.—Reported that Mr. D. T. Richards had resumed his place on this Committee on his return from leave. Thanks to Mr. F. A. Bond for his services while acting for Mr. Richards were recorded.

The Chairman then said with the permission of the Board he would next take item 5 (*d*) in order not to detain Mr. Whitehead who had kindly attended to advise the Board on this matter.

5(d). **EMPIRE DRIER AND REORGANIZATION OF ST. COOMBS ROLLING ROOM**

The Chairman said details of the proposed scheme, which was concerned with alterations and repairs to the Empire Drier and the enlargement of the rolling room to provide additional space for experimental work, had been given in the Minutes of the Estate and Experimental Committee which had been circulated to Members. The scheme was supported by this Committee and had been considered by the Finance Committee that morning.

The Finance Committee were in favour of the scheme in so far as technical and financial considerations were concerned. The only question was one of principle in regard to whether under present conditions the use of the required steel work was justifiable. The Committee referred this point for the opinion of the Board.

The Chairman asked the Financial Secretary for his view on this question.

Mr. Huxham said supplies of steel were very limited indeed and there would be great difficulty in obtaining further imports. He considered present stocks should be used with the greatest caution and envisaged possible Government control of this commodity.

Mr. Whitehead then gave details of the scheme. He stressed that immediate expenditure for the protection of the Empire drier were essential, and that if the scheme as a whole were not carried out much of this would be nullified and ultimately heavier expenditure would have to be incurred. He said more space was urgently required if the Institute was to have the means for adequate experimental work on machinery and plant. He stressed that the drying room was out-of-date and that St. Coombs factory should not be allowed to fall behind modern practice in its lay out.

In regard to the question of steel work, Mr. Whitehead said in reconstructing the existing verandah and enlarging this, all existing steel work and roofing material would be used again and the amount of new steel work required was very small in amount and could all be supplied from existing stock in Ceylon, of which it would form but a negligible fraction.

Substantial annual and recurring savings would result from reduced insurance charges and lower upkeep charges, particularly in regard to chimney renewals.

Mr. Hamilton suggested that all steel uprights should be replaced by reinforced concrete pillars.

It was decided to adopt this modification and the Board after further discussion sanctioned a sum of Rs. 22,000 for putting into effect Mr. Whitehead's plan. This sum includes estate obligations.

In reply to Mr. Perera, the Director said the work of moving and re-erecting the driers would in each case be carried out by the Agents for the machine concerned.

The Chairman thanked Mr. Whitehead for attending and advising the Board, and Mr. Whitehead then left the meeting.

4. **FINANCE**

(*a*) *Audited Accounts for 1940 and Auditors' Reports thereon.*

The Chairman referred to the satisfactory financial position as shown by the accounts for 1940 from which he quoted figures in regard to various items of

receipt and expenditure. It was noted that the liability under depreciation reserve, now amounting to Rs. 399,362, was covered by cash and liquid assets to the extent of nearly 71 per cent.

In regard to the Estate Working Account, the profit at Rs. 46,507 was the highest yet recorded for St. Coombs.

It was reported that 113,977 pounds of tea had been supplied to the Ministry of Food at an average price under the two contracts of 83·25 cents and 42,391 pounds sold on the local market at an average price of Rs. 1·01 gross.

The Audited Accounts were accepted.

Auditors' Reports.—The Chairman said these were of the usual satisfactory nature and there was little in them on which comment was required. The following matters had been considered by the Finance Committee.

(i.) *Insurance.*—The Finance Committee were satisfied that insurance cover was adequate.

(ii.) *Depreciation.*—The Board accepted the recommendation of the Finance Committee that the present practice should be continued whereby depreciation is not written off furniture, renewals being met from revenue account.

In regard to depreciation generally, the Financial Secretary suggested that at a later date the question of limiting against depreciation might be considered.

(iii.) *Motor Roller and Motor Car.*—The Board approved the arrangements made by the Director in allocating depreciation in these two items.

(iv.) It was agreed at the suggestion of Mr. Hoare that at the end of the present year the Director would present a statement showing the distribution of capital expenditure up-to-date as between the Estate and Research side.

(*b*) *Institute's Account for February, 1941.*

Reported that a further sum of Rs. 50,000 had been invested in Ceylon Government 2½ per cent. War Loan.

The Accounts were accepted.

(*c*) *Investments.*

The Director reported that the Attorney-General had ruled that the Institute could not place funds in the Interest free loan; it had also been found that the Institute could not purchase Ceylon Savings Certificates.

The Board confirmed the decision taken by circulation of papers to make the above investment of Rs. 50,000.

In regard to future investments, the Chairman said while there was an appreciable amount of cash in hand, receipts from the cess and tea sales would be slow in coming in during the first few months of the year. He thought therefore a fairly large sum should be kept free to finance current expenditure.

The Financial Secretary hoped the Board would not be too cautious in this respect and invest as much as possible of its funds in the War Loans.

After discussion, in which the question of advances from different banks against War Loans was considered, the Board asked the Chairman and Director

to review the position at the end of each month so that any sum available, even if small in amount, might be invested at as early a date as possible.

(*d*) *1941 Estimates.*

(i.) Recorded that the amount voted in 1940 against capital/expenditure for the Maternity Home and Lines and unexpended at the end of the year was Rs. 6,863. This sum was revoted under 1941 A/c.

(ii.) Estate Accounts. Vote 65, Engine Running Costs. The Board approved the recommendation of the Finance Committee that the T. R. I. contribution to this vote be increased by 20 per cent. in consequence of the increased cost of fuel and oil.

(iii.) The Board sanctioned an additional vote of Rs. 180 under Research Estimates, vote 46, for replacement of the kitchen stove in the Director's bungalow.

(iv.) Estimated Receipts. It was noted that receipts under the cess were likely to be reduced by about Rs. 6,600 owing to restriction being increased to 10 per cent.

5. ST. COOMBS ESTATE

(*a*) *Visiting Agent's Report.*

Labour Out-turn. An error in the report was corrected, the average out-turn being 76 per cent. and not 68 per cent as recorded.

(*b*) *Disposal of St. Coombs Crop, 1941.*

Reported that 116,550 pounds had been accepted by the Tea Commissioner at an average price of 83·55 cents. The necessary agreement had been signed that morning. (Authority, Circular No. 6/41 of March 5, 1941).

(*c*) *Water Sanitation, St. Coombs Estate.*

The Board considered this scheme as detailed in the recommendation of the Estate and Experimental Committee. The Chairman reported that the Finance Committee had recommended that sanction should be accorded.

The Director gave details of the procedure to be adopted and the Board approved expenditure of :—

(i) Rs. 500 for increased water storage facilities.
(ii) Rs. 4,800 for providing water sanitation to the two new sets of lines, existing Nos. 1 and 2 lines and the factory latrine.

(*d*) *Use of St. Coombs Road by Kowlahena and Waltrim Estates.*—Reported that the agreement on the above matter had been duly signed. (Authority Circular No. A. 3/41 of February 3).

6. MINUTES OF THE 46TH MEETING OF THE ESTATE AND EXPERIMENTAL COMMITTEE HELD ON MARCH 22, 1941

Most of the items had already been discussed under previous business.

The Director enlarged on the fertilizer position and stated that he had written to the Planters' Association of Ceylon and the Ceylon Estates

Proprietory Association in regard to further rationing of Ammonium Sulphate and and Nitrate of Soda. The position would be that :—

(i.) Mineral Nitrogen would be restricted to one-third of the total nitrogen in tea mixtures.

(ii.) Nitrogen in the form of Ammonium Sulphate would be limited to one-sixth of the total nitrogen.

The Director said in future much larger supplies of groundnut cake would be required and he was making inquiries about the position from the Director of Agriculture, Madras.

In this connection, the Financial Secretary pointed out that there might be difficulties about freight from India and rates were being largely increased. The Director said he would maintain touch with the Fertilizer Firms on this subject.

In reply to Mr. Hoare, the Director said they had obtained no evidence to support the view that weed seeds were imported in groundnut cake.

The minutes of the Estates and Experimental Committee were recorded.

7. SENIOR SCIENTIFIC STAFF

(i.) Reported that Mr. C. B. R. King had received a Commission as Pilot Officer in the R. A. F. V. R. (Administrative Branch) and left Ceylon on service in January.

(ii.) Reported that Captain Tubbs had been promoted Major in January.

(iii.) The Director conveyed Dr. Eden's thanks to the Board in connection with his promotion to the Selection Grade.

8. JUNIOR SCIENTIFIC STAFF

(i.) *Small Holdings Officer, Gampola.*—Reported that as a result of representations to the O. C., C. L. I., Mr. Illankoon was now being relieved for a period of two weeks every two months to attend to his civil duties.

(ii.) *Small Holdings Officer, Baddegama. Advance for Car.*—The Board accepted the recommendation of the Finance Committee that an advance of Rs. 2,323 be sanctioned for the purchase of a car for official use.

9. TEA SCIENTIFIC CONFERENCE, SOUTH INDIA

The Board approved the Director's suggestion that Dr. Gadd should be deputed to attend the Tea Scientific Conference to be held by the United Planters' Association of South India in August, 1941, and voted a sum of Rs. 500 for the expenses of this visit. It was noted Dr. Gadd would at the same time visit the U. P. A. S. I. Tea Experimental Station and certain estates in South India.

10. RECREATIONAL FACILITIES—SUBORDINATE STAFF

The Board sanctioned expenditure of Rs. 50 for the provision of a Volley Ball Court for the Subordinate Staff.

The Research Institute of Ceylon,
St. Coombs, Talawakele.

ROLAND V. NORRIS,
Secretary.

4——J. N. A 3984 (6/41)

CORRESPONDENCE

A Leaf Spot Disease of Annual Phlox.

Tea Research Institute,
St. Coombs,
Talawakele, Ceylon,
24th May, 1941.

The Editor,
The Tropical Agriculturist,
Department of Agriculture,
Peradeniya.

DEAR SIR,

WITH reference to my article entitled "A Leaf Spot Disease of Annual Phlox" which appeared in *The Tropical Agriculturist* Vol. XCVI, No. 3, it has been brought to my notice that there is a record of leaf spot of *Phlox drummondi* caused by *Septoria drummondii* on page D43 of the Administration Report of the Director of Agriculture, Ceylon, for the year 1938. The statement expressed in my paper that the fungus was new to Ceylon requires amendment in the light of this observation.

Yours faithfully,
T. E. T. BOND.

The Premature Fall of Coconuts

To
The Editor,
The Tropical Agriculturist,
Peradeniya.

SIR,

I HAVE read with great interest your editorial on "The Premature Fall of Coconuts" appearing in the May (1941) issue of *The Tropical Agriculturist*.

You refer to 3 likely causes :—(1) Direct physical injury to the bunch stalk or the individual nut, (2) Physiological factors produced by inadequate soil moisture and (3) A fungus disease which is most active in wet weather.

Of the last mentioned 2 causes fungus disease due to wet conditions is likely to be chiefly prevalent in the Wet Zone with its large rainfall throughout the year.

In the Dry Zone, inadequate soil moisture is the most likely cause. I have observed in coconut estates in Jaffna that a slight shower of rain following a prolonged drought brought about a large fall of immature coconuts, but if the drought is followed by heavy rain the fall was not appreciable.

In the case of human beings also slight rain after a long drought leads to the general prevalence of such complaints as sore eyes and particularly so in the case of persons who walk barefoot.

It is known that cattle are liable to certain diseases during seasons of prolonged drought.

Can it be that these results are due to the sudden exudation of heat from a non-cooled soil when insufficient rain falls? The matter is worth investigation.

I am, Sir,
Yours in service,

Jaffna. Sgd. C. ARULAMBALAM.

5——J. N. A 3984 (6/41)

ANIMAL DISEASE RETURN FOR THE MONTH ENDED MAY, 1941

Province, &c.	Disease	No. of Cases up to date since January, 1941	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Foot-and-mouth disease	1	..	..	1	..	..
	Rabies	10	1	5	..	..	5
Colombo Municipality	Foot-and-mouth disease	1	..	..	1	..	..
	Rabies	19	3	19	..	..	..
	Hæmorrhagic Septicæmia	1	..	..	1	..	..
Cattle Quarantine Station	Anthrax	12	..	12	..	..	..
Central	Foot-and-mouth disease	2	..	..	2	..	..
	Contagious Abortion	1	1	..	..	1	..
	Rabies	33	..	6	..	..	27
	Piroplasmosis	4	3	1	3	..	..
	Bovine Tuberculosis	6	..	..	..	..	6
Southern	Foot-and-mouth disease	43	..	2	41	..	..
	Rabies	8	..	..	..	..	8
Northern	Foot-and-mouth disease	248	10	..	248	..	..
Eastern	Foot-and-mouth disease	65	..	7	58	..	..
	Rabies	4	..	..	..	..	4
North-Western	Anthrax	18	..	18	..	..	..
	Rabies	5	..	..	..	..	5
	Contagious Mange	8	..	1	7	..	..
North-Central	Hæmorrhagic Septicæmia	43	..	43	..	..	..
Sabaragamuwa	Rabies	5	2	3	..	..	2
	Piroplasmosis	4	..	..	4	..	..

Department of Agriculture,
Peradeniya, June 20, 1941.

M. CRAWFORD,
Deputy Director of Agriculture (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, MAY, 1941

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Agalawatta ..	87·8	+1·2	75·2	+0·6	84	93	6·2	41·91	28	—
Anuradhapura ..	91·5	+1·8	77·3	+1·4	72	91	7·4	8·00	10	+ 4·87
Badulla ..	84·9	+0·2	68·2	+1·9	74	95	6·4	9·92	19	+ 5·24
Batticaloa ..	91·7	+1·7	79·4	+1·8	68	85	6·1	0·12	2	— 1·77
Colombo ..	88·3	+1·7	77·6	+0·1	76	89	8·4	13·50	22	— 1·48
Diyatalawa ..	78·6	0	63·6	+1·7	72	89	7·6	5·25	20	— 0·61
Galle ..	86·1	+1·5	78·5	+0·7	74	82	7·0	18·07	25	+ 5·60
Hakgala ..	73·2	+0·2	58·6	+0·7	86	94	6·8	17·48	19	+ 9·52
Hambantota ..	88·3	+1·9	78·3	+1·1	76	89	7·3	4·14	10	+ 0·71
Jaffna ..	90·4	+2·7	83·0	+1·5	76	83	6·1	0·36	6	— 1·29
Kandy ..	87·9	+1·7	71·8	+0·8	75	92	8·0	12·83	20	+ 6·84
Kurunegala ..	90·6	+2·0	76·5	+0·9	74	93	7·6	9·22	24	+ 2·54
Lunuwila ..	89·0	+1·8	78·2	+1·2	76	91	7·2	7·25	20	—
Mannar ..	90·9	+1.5	81·4	+0·8	72	83	8·3	1·11	8	— 0·79
Nuwara Eliya ..	70·6	+0·3	54·5	+1·1	82	97	8·9	20·05	22	+13·17
Puttalam ..	90·3	+2·6	79·0	+0·5	74	89	7·5	3·80	10	+ 0·06
Ratnapura ..	90·0	+1·8	75·7	+0·9	81	93	8·0	30·40	26	+10·33
Talawakele ..	74·2	—0·6	60·5	+0·6	80	91	8·4	27·36	26	—
Trincomalee ..	90·8	—0·7	80·5	+1·9	67	82	6·7	2·42	5	— 1·03

The rainfall for May was above average except in the north of the Island and some west coastal districts, and along the east coast. Excesses were particularly marked in the south-west, specially near the hills.

The largest excesses were 29·12 inches at Carchilmally, 28·32 inches at Kenilworth, 26·94 inches at Norton Bridge, 26·77 inches at Hatton and 25·79 inches at Helboda, while more than a dozen other stations also recorded excesses of over 20 inches. The largest deficit was 3·91 inches at Palugaswewa.

The highest monthly totals were 51·65 inches at Kenilworth, 49·84 inches at Kokkawita and 49·06 inches at Carney. Six stations, nearly all on the east coast, received no rain at all.

There were altogether 150 daily falls of 5 inches and over reported during May, of which 15 falls were 10 inches and over. More than two-thirds of these occurred on the 21st and 22nd. The largest fall was 20·95 inches at Kenilworth on the 22nd. The previous record at this station was 20·19 inches on October 4, 1913. Other large falls during the month included 15·24 inches at Padupola on the 22nd, and 14·32 inches at Kokkawita on the 21st.

Intermonsoon weather that was prevalent in April persisted well into May, and during the first two-thirds of the month scattered showers of local thunderstorm origin were generally experienced. South-west monsoonal conditions did not appear till about the 20th, rather later than in most years. A steep south-westerly pressure gradient rapidly developed, and on the 21st and the following days heavy monsoon rains accompanied by pronounced squally conditions were experienced in the south-west of the Island. Towards the end of the month weather conditions moderated appreciably, with resultant decrease of rain.

Temperatures were consistently above average. The highest shade temperature recorded was 98·7° at Batticaloa on the 25th, while the lowest temperature was 49·3° at Nuwara Eliya on the 1st. Humidity was generally above average, while cloud amounts were in excess. Surface winds were above normal strength, the predominant direction being south-westerly.

D. T. E. DASSANAYAKE,
Superintendent, Observatory.